EUROPEAN PATENT SPECIFICATION


(54) SUSTAINED RELEASE PREPARATION OF A MACROLIDE
MAKROLID-FORMULIERUNG MIT VERZÖGERTER WIRKSTOFFABGABE
PREPARATIONS A LIBERATION PROLONGEE D’UN MACROLIDE

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU NL PT SE
Designated Extension States:
SI

(30) Priority: 26.03.1998 JP 7903998
29.06.1998 JP 18296398

(43) Date of publication of application:
03.01.2001 Bulletin 2001/01

(60) Divisional application:
04002277.4 / 1 421 939

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Description

TECHNICAL FIELD

[0001] The present invention relates to a formulation containing a macrolide compound and being endowed with an ability of an extremely excellent sustained-release, for use in a medical field.

BACKGROUND OF THE INVENTION

[0002] An oral formulation of one of macrolide compounds, namely tacrolimus with an useful immunosuppressive activity, has been prepared as a solid dispersion composition, which possesses a rapid-release characterization by using polymers such as hydroxypropylmethyl cellulose and disintegrator (see for example EP 0 240 773). Owing to the presence of disintegrator therein, it is a rapid-release formulation. It has been appraised highly in clinical field owing to its high absorbability. In clinical practice, alternatively, the emergence of an oral tacrolimus formulation with a sufficient long action and excellent oral absorbability has been expected.

[0003] However, it is the state of the art for a person skilled in the art that the absorbability of a pharmaceutically active agent given orally in a manner as sustained-release formulation is generally reduced and/or that a non-negligible variation of the absorbability is observed. The inventors of the invention have carried out a lot of investigations. Consequently, the inventors have invented sustained-release formulations of macrolide compounds, the representative of which is tacrolimus, characterized in that macrolide compound is excellently absorbed orally and/or that variation of its absorbability is suppressed.

DISCLOSURE OF THE INVENTION

[0004] The present invention relates to a sustained-release formulation of a macrolide compound, wherein the dissolution of the macrolide compound is under sustained release.

[0005] It is an object of the invention to provide a sustained-release formulation of a macrolide compound, wherein the time (T63.2%) required for 63.2 % of the maximum amount of macrolide compound to be dissolved is 0.7 to 15 hours, as measured according to the Japanese Pharmacopoeia, the 13-th edition, Dissolution Test, No. 2 (Paddle method, 50 rpm) using a test solution which is an aqueous 0.005 % hydroxypropyl cellulose solution, adjusted to pH 4.5.

[0006] It is the other object of the invention to provide a solid dispersion composition of a macrolide compound usable in the sustained-release formulation mentioned above, wherein the macrolide compound is present as an amorphous state in a solid base.

[0007] The T63.2% value as determined by the dissolution test in accordance with this invention can be estimated from the release curve constructed by plotting test data on graph paper. However, the release profile of a drug can be generally analyzed by fitting dissolution test data to a release model and such a method can also be used in the computation of said T63.2% value. The model for fitting which can be used includes the first-order or linear model, zero-order model, cube-root model, etc. as described in Yamaoka, K. & Yagahara, Y.: Introduction to Pharmacokinetics with a Microcomputer, Nankodo, p.138 but as a model by which all kinds of release patterns can be expressed with the highest validity, there is known Weibull function, which is described in the above book and L. J. Leeson & J. T. Carstensen (ed.): Release of Pharmaceutical Products (American Pharmaceutical Society) (Chizin Shokan), p. 192-195.

[0008] Weibull function is a function such that the dissolution rate (%) in time (T) can be expressed by the following equation:

$$\text{Dissolution rate (\%)} = D_{\text{max}} \times \left\{1 - \exp\left[-\left((T-T_i)/\text{m}\right)^n\right]\right\}$$

where $D_{\text{max}}$ represents the maximum dissolution rate at infinite time, m is a scale parameter representing the dissolution velocity, n is a shape parameter representing the shape of the dissolution curve, Ti is a position parameter representing the lag time till start of dissolution, and the dissolution characteristic of a pharmaceutical product can be expressed by using those parameters in combination.

[0009] In order to fit dissolution test data to Weibull function and calculate the respective parameters, the nonlinear least square method described in Yamaoka, K. & Yagahara, Y.: Introduction to Pharmacokinetics with a Microcomputer, Nankodo, p.40, mentioned above, is used. More particularly, the parameters are determined at the point of time where the sum of the squares of differences between the values calculated by the above equation and the measured values at each point of time is minimal and the dissolution curve calculated by means of the above equation using those parameters is the curve which dose most faithfully represent the measured values.
The meaning of each parameter of Weibull function is now explained.

\[ D_{\text{max}} \]  (maximum dissolution rate) is the maximum dissolution rate at infinity of time as mentioned above and generally the value of \( D_{\text{max}} \) is preferably as close to 100 (\%) as possible.

\[ m \]  (scale parameter) is a parameter representing the dissolution velocity of a pharmaceutical product, and the smaller the value of \( m \) is, the higher is the dissolution velocity and similarly the larger the value of \( m \) is, the lower is the dissolution velocity.

\[ n \]  (shape parameter) is a parameter representing the shape of a dissolution curve. When the value of \( n \) is 1, Weibull function can be written as dissolution rate (\%) = \( D_{\text{max}} \times (1-\exp[-(T-\text{Ti})/m]) \), and since this is equivalent to first-order kinetics, the dissolution curve is linear. When the value of \( n \) is smaller than 1, the dissolution curve plateaus off. When the value of \( n \) is larger than 1, a sigmoid dissolution curve prevails.

\[ \text{Ti} \]  (position parameter) is a parameter representing the lag time till start of dissolution.

The sustained-release formulation comprising a macrolide compound according to this invention can also be characterized by means of said Weibull function. Thus, the objective sustained-release formulation can be implemented by setting \( D_{\text{max}} \) (maximum dissolution rate) at 80% or more, preferably 90% or more, more preferably 95% or more, \( m \) (scale parameter) at 0.7~20, preferably 1~12, more preferably 1.5~8, \( n \) (shape parameter) at 0.2~5, preferably 0.3~3, more preferably 0.5~1.5, and \( \text{Ti} \) (position parameter) at 0~12, preferably 0~8, and more preferably 0~4.

The value found by substituting the parameter values of \( m \) and \( n \) from the above Weibull function into the term \( m^{1/n} \) represents the time in which 63.2% of the maximum amount of dissolution of the active ingredient is released from the formulation (T63.2%). That is to say, \( T_{63.2\%} \) (hr) = \( m^{1/n} \). The release characteristic of the sustained-release formulation of this invention can be evaluated by the Dissolution Test, Method 2 (Paddle method, 50 rpm) of JP XIII using a test solution which is 0.005% aqueous solution of hydroxypropyl cellulose adjusted at pH 4.5. In the sustained-release formulation comprising a macrolide compound according to this invention, the time\( (T_{63.2\%}) \) in which 63.2% of the maximum amount of the macrolide compound to be dissolved is released from the formulation is 0.7~15 hours.

In the past, though the rapid-release formulation comprising macrolide compound has already been produced, any sustained-release formulations, T63.2% of which is 0.7~15 hours and which would be quite useful in clinical practice, have never been produced. The present invention completed it for the first time. If the T63.2% value is shorter than 0.7 hour, the efficacy of the macrolide compound following oral administration will not be sufficiently sustained. When the formulation has a T63.2% value of more than 15 hours, the release of the active ingredient will be so retarded that the active ingredient will be eliminated from the body before the effective blood concentration is reached, thus being unsuited as the formulation of this invention. When T63.2% is 1.0~12 hours, a more favorable sustained-release can be achieved. More preferably, T63.2% is 1.3~8.2 hours, and the most preferred is a sustained-release formulation with a T63.2% value of 2~5 hours.

The term "macrolide compound" for use in accordance with the invention is the generic name of compounds with 12 members or more, which belong to large-ring lactones. Abundant macrolide compounds generated by micro-organisms of the genus Streptomyces, such as rapamycin, tacrolimus (FK506), and ascomycin, and the analogs and derivatives thereof are included in the term macrolide compound.
In addition to the above definitions, Y, R10 and R23, together with the carbon atoms to which they are attached, may represent a saturated or unsaturated 5- or 6-membered nitrogen, sulfur and/or oxygen containing heterocyclic ring optionally substituted by one or more groups selected from the group consisting of an alkyl, a hydroxy, an alkoxy, a benzyl, a group of the formula -CH2Se(C6H5), and an alkyl substituted by one or more hydroxy groups.

References:

[0019] Preferable R24 may be cyclo(C5-7)alkyl group, and the following ones can be exemplified.

(a) a 3,4-di-oxo-cyclohexyl group;
(b) a 3-R20,4-R21-cyclohexyl group,
in which

R20 and R21 together form an oxygen atom in an epoxide ring; or

(c) cyclopentyl group substituted by methoxymethyl, optionally protected hydroxymethyl, acyloxymethyl (in which the acyl moiety optionally contains either a dimethylamino group which may be quaternized, or a carboxy group which may be esterified), one or more amino and/or hydroxy groups which may be protected, or aminooxalylloxymethyl. A preferred example is a 2-formyl-cyclopentyl group.

[0020] The definitions used in the above general formula (I) and the specific and preferred examples thereof are now explained and set forth in detail.

[0021] The term "lower" means, unless otherwise indicated, a group having 1 to 6 carbon atoms.

[0022] Preferable examples of the "alkyl groups" and an alkyl moiety of the "alkoxy group" include a straight or branched chain aliphatic hydrocarbon residue, for example, a lower alkyl group such as methyl, ethyl, propyl, isopropyl, butyl, isobutyl, pentyl, neopentyl and hexyl.

[0023] Preferable examples of the "alkenyl groups" include a straight or branched chain aliphatic hydrocarbon residue having one double-bond, for example, a lower alkenyl group such as vinyl, propenyl (e.g., allyl group), butenyl, meth-
ypropenyl, pentenyl and hexenyl.

[0024] Preferable examples of the "aryl groups" include phenyl, tolyl, xylyl, cumenyl, mesityl and naphthyl.

[0025] Preferable protective groups in the "protected hydroxy groups" and the protected amino are 1-(lower alkythio) -(-lower)alkyl group such as a lower alkythiomethyl group (e.g., methylthiomethyl, ethylthiomethyl, propylthiomethyl, isopropylthiomethyl, butylthiomethyl, isobutylthiomethyl, hexylthiomethyl, etc.), more preferably C1-C4 alkylthiomethyl group, most preferably methythiomethyl group; trisubstituted silyl group such as a tri(lower)alkylsilyl (e.g., trimethylsilyl, triethylsilyl, tributylsilyl, tert-butyl(dimethyl)silyl, tri-tert-butylsilyl, etc.) or lower alkyldiarylsilyl group, most preferably tert-butyl(dimethyl)silyl group and tert-butyldiphenylsilyl group; and an acyl group such as an aliphatic, aromatic acyl group substituted by an aromatic acyl group which are derived from a carboxylic acid, sulfonic acid or carboxylic acid.

[0026] Examples of the aliphatic acyl groups include a lower alkanoyl group optionally having one or more suitable substituents such as carboxy, e.g., formyl, acetyl, propionyl, butyryl, isobutryl, valeryl, isovaleryl, pivaloyl, hexanoyl, carboxyacetyl, carboxypropionyl, carboxybutyryl, carboxyhexanoyl, etc.; a cyclo(lower)alkoxy(lower)alkanoyl group optionally having one or more suitable substituents such as lower alkyldiphenylsilyl, propyldiphenylsilyl, tert-butyldiphenylsilyl, etc.; a camphorsulfonyl group; or a lower alkylcarbamoyl group optionally having one or more suitable substituents such as carboxy or protected carboxy, for example, carboxy (lower)alkylcarbamoyl group (e.g., carboxymethylcarbamoyl, carboxypropionylcarbamoyl, carboxybutyrylcarbamoyl, carboxypentylcarbamoyl, carboxyhexylcarbamoyl, etc.), tri-(lower)alkylsilyl (lower)alkoxy (lower)alkylcarbamoyl group (e.g., trimethylsilylmethoxy carbonylcarbomethyl, trimethylsilyloxy carbonylpropylcarbamoyl, triethylysilyloxycarbonylpropylcarbamoyl, tert-butyldimethylsilylcarboxypropylcarbamoyl, tert-butyldimethylsilylthi oxycarbonylpropylcarbamoyl, tri-methylsilylpropoxy carbonylbutylcarbamoyl, etc.) and so on.

[0027] Examples of the aromatic acyl groups include an aryl group optionally having one or more suitable substituents such as nitro, e.g., benzoyl, toluoyl, xyloyl, naphthoyl, nitrobenzoyl, dinitrobenzoyl, nitronapthoyl, etc.; and an arenesulfonyl group optionally having one or more suitable substituents such as halogen, e.g., benzenesulfonyl, toluenesulfonyl, xylenesulfonyl, naphthalenesulfonyl, fluorobenzenesulfonyl, chlorobenzenesulfonyl, bromobenzenesulfonyl, iodobenzenesulfonyl, etc.

[0028] Examples of the aromatic acyl groups include an aromatic acyl group optionally having one or more suitable substituents such as nitro, e.g., benzoyl, toluoyl, xyloyl, naphthoyl, nitrobenzoyl, dinitrobenzoyl, nitronapthoyl, etc.; and an arenesulfonyl group optionally having one or more suitable substituents such as halogen, e.g., benzenesulfonyl, toluenesulfonyl, xylenesulfonyl, naphthalenesulfonyl, fluorobenzenesulfonyl, chlorobenzenesulfonyl, bromobenzenesulfonyl, iodobenzenesulfonyl, etc.

[0029] More preferable acyl groups among the aforesaid acyl groups are C1-C4 alkanoyl group optionally having carboxy, cyclo(C2-C6)alkoxy(C1-C4)alkanoyl group having two (C1-C4) alkyds at the cycloalkyl moiety, camphorsulfonyl group, carboxy-(C1-C4)alkylcarbamoyl group, tri(C1-C4)alkylsilyl-(C1-C4)alkoxycarbonyl-(C1-C4)alkylcarbamoyl group, benzoyl group optionally having one or two nitro groups, benzenesulfonyl group having halogen, or phenyl (C1-C4)alkanoyl group having C1-C4 alkoxy and trihalo(C1-C4)alkyl group. Among these, the most preferable ones are acetyl, carboxypropionyl, menthyloxyacetyl, camphorsulfonyl, benzoyl, nitrobenzoyl, dinitrobenzoyl, iodobenzenesulfonyl and 2-trifluoromethyl-2-phenoxyacetyl, etc.

[0030] Preferable examples of the "5- or 6-membered nitrogen, sulfur and/or oxygen containing heterocyclic ring" include a pyrrolidinyl group and a tetrahydrofurfuryl group.

[0031] "A heteroaryl which may be substituted by suitable substituents" moiety of the "heteroaryloxy which may be substituted by suitable substituents" may be the ones exemplified for R1 of the compound of the formula of EP-A-532,088, with preference given to 1-hydroxyethylindol-5-yl, the disclosure of which is incorporated herein by reference.


[0033] Particularly, the compounds which are designated as FR900506 (=FK506), FR900520 (ascomycin), FR900523, and FR900525 are products produced by microorganisms of the genus Streptomyces, such as Streptomycetes tsukubaensis No. 9993 (deposited with National Institute of Bioscience and Human Technology Agency of Industrial Science and Technology (formerly Fermentation Research Institute Agency of Industrial Science and Technology), at 1-3, Higashi 1-chome, Tsukuba-shi, Ibaraki, Japan, date of deposit October 5, 1984, accession number FERM BP-927) or Streptomycetes hysoginosporus subsp. yakushimaensis No. 7238 (deposited with National Institute of Bioscience and Human Technology Agency of Industrial Science and Technology (formerly Fermentation Research Institute Agency of Industrial Science and Technology), at 1-3, Higashi 1-chome, Tsukuba-shi, Ibaraki, Japan, date of
The preferred examples of the tricyclic compounds (I) are the ones, wherein each of adjacent pairs of $R^3$ and $R^4$ or $R^5$ and $R^6$ independently form another bond formed between the carbon atoms to which they are attached; each of $R^8$ and $R^{23}$ is independently a hydrogen atom;

- $R^8$ is a hydroxy group;
- $R^{10}$ is a methyl group, an ethyl group, a propyl group or an allyl group;
- $X$ is (a hydrogen atom and a hydrogen atom) or an oxo group;
- $Y$ is an oxo group;
- each of $R^{14}$, $R^{15}$, $R^{16}$, $R^{17}$, $R^{18}$, $R^{19}$, and $R^{22}$ is a methyl group;
- $R^{24}$ is a 3-$R^{20}$-4-$R^{21}$-cyclohexyl group, in which
  - $R^{20}$ is hydroxy, an alkoxy group, an oxo group, or a -OCH$_2$OCH$_2$CH$_2$OCH$_3$ group, and
  - $R^{23}$ is hydroxy, -OCN, an alkoxy group, a heteroaryloxy which may be substituted by suitable substituents, a -OCH$_2$OCH$_2$CH$_2$OCH$_3$ group, a protected hydroxy group, chloro, bromo, iodo, aminoxyloxy, an azido group, p-toloyloxythiocarbonyloxy, or $R^{25}$R$^{26}$CHCOO-,
    - in which
      - $R^{25}$ is optionally protected hydroxy or protected amino, and
      - $R^{26}$ is hydrogen or methyl, or
  - $R^{20}$ and $R^{21}$ together form an oxygen atom in an epoxide ring; and
- $n$ is an integer of 1 or 2.

The most preferable tricyclic compounds (I) are, in addition to FK506, ascomycin derivatives such as halogenated-ascomycin (e.g., 33-epi-chloro-33-desoxysacomicyn), which is disclosed in EP 427,680, example 66a.

The tricyclic compounds (I) have a similar basic structure, i.e., tricyclic macrolide structure, and at least one of the similar biological properties (for example, immunosuppressive activity).

The tricyclic compounds (I) may be in a form of its salt, which includes conventional non-toxic and pharma-
ceptually acceptable salt such as the salt with inorganic or organic bases, specifically, an alkali metal salt such as sodium salt and potassium salt, an alkali earth metal salt such as calcium salt and magnesium salt, an ammonium salt and an amine salt such as triethylamine salt and N-benzyl-N-methylamine salt.

With respect to the macrolide compound used in the present invention, it is to be understood that there may be conformers and one or more stereoisomers such as optical and geometrical isomers due to asymmetric carbon atom(s) or double bond(s), and such conformers and isomers are also included within the scope of macrolide compound in the present invention. And further, the macrolide compounds can be in the form of a solvate, which is included within the scope of the present invention. The solvate preferably include a hydrate and an ethanolate.

The sustained-release formulation in accordance with the present invention is a formulation comprising a solid dispersion composition, wherein the macrolide compound is present as an amorphous state in a solid base, which shows its T 63.2% value is 0.7 to 15 hours. The presence or absence of a diffraction peak detected by X-ray crystallography, thermal analyses, and so on indicates whether or not a macrolide compound is present as an amorphous state in a solid base in the solid dispersion composition.

The solid base of the invention is a water-insoluble pharmaceutically acceptable bases capable of retaining the macrolide compound as an amorphous state and being at the solid state at ambient temperature, selected from, wax and water-insoluble polymers.

Specifically, preferable examples of wax include glycerin monostearate and sucrose fatty acid esters [for example, mono-, di- or triesters of sucrose with moderate to higher fatty acids, with 8 to 20 carbon atoms, for example caprylic acid, capric acid, lauric acid, myristic acid, palmitic acid, stearic acid, arachic acid, behenic acid, oleic acid, linoleic acid, etc.]. Additional examples of wax include polyglycerin fatty acid ester. Any polyglycerin fatty acid ester including monoester, diester or polyester of polyglycerin with fatty acid is satisfactory. Specific examples of polyglycerin fatty acid ester include for example behenate hexa(tetra)glyceride, caprylate mono(deca)glyceride, caprylate di(tri) glyceride, caprate di(tri)glyceride, laurate mono(tetra)glyceride, laurate mono(hexa)glyceride, laurate mono(deca)glyceride, oleate mono(tetra)glyceride, oleate mono(hexa)glyceride, oleate mono(deca)glyceride, oleate di(tri)glyceride, oleate di(tetra)glyceride, oleate sesqui(deca)glyceride, oleate penta(tetra)glyceride, oleate penta (hexa)glyceride, oleate deca(deca)glyceride, linoleate mono(hexa)glyceride, linoleate di(tri)glyceride, linoleate di(tetra)glyceride, linoleate di(hexa)glyceride, stearate mono(di)glyceride, stearate mono(tetra)glyceride, stearate mono(hexa)glyceride, stearate mono(deca)glyceride, stearate tri(tetra)glyceride, stearate tri(hexa)glyceride, stearate sesqui (hexa)glyceride, stearate penta(tetra)glyceride, stearate penta(hexa)glyceride, stearate deca(deca)glyceride, palmitate mono(tetra) glyceride, palmitate mono(hexa)glyceride, palmitate mono(deca)glyceride, palmitate tri(tetra)glyceride, palmitate tri (hexa)glyceride, palmitate sesqui(hexa)glyceride, palmitate penta (tetra) glyceride, palmitate penta(hexa)glyceride, and palmitate deca (deca) glyceride. Preferable polyglycerin fatty acid esters are for example behenate hexa (tetra) glyceride [for example, Poem J-46B under a trade name, manufactured by Riken Vitamin Co., Ltd.], stearate penta (tetra)glyceride [for example, PS-310 under a trade name, manufactured by Sakamoto Yakuhin Kogyo Co., Ltd.], stearate sesqui (hexa)glyceride [SS-500 under a trade name, manufactured by Sakamoto Yakuhin Kogyo Co., Ltd.], stearate mono(hexa)glyceride, and a mixture thereof. More preferable waxes are glycerin monostearate and low-HLB sucrose fatty acid ester [for example, F-50, F-20, F-10, etc., manufactured by Dai-i-chi Kogyo Seiyaku Co., Ltd.].

The weight ratio of the macrolide compound and wax is preferably 1 : 10 to 1 : 100, more preferably 1 : 40 to 1 : 60, when the wax is for example glycerin monostearate; the weight ratio thereof is preferably 1 : 0.2 to 1 : 20, more preferably 1 : 0.5 to 1 : 5, when the wax is for example sucrose fatty acid ester; the weight ratio thereof is preferably 1 : 0.1 to 1 : 100, more preferably 1 : 0.5 to 1 : 50, when the wax is polyglycerin fatty acid ester.

Preferable water-insoluble polymers include for example ethylcellulose, methacrylate copolymers (for example, Eudragits such as Eudragit E, R, S, RS, LD, etc.). In case that the water-insoluble polymer is ethylcellulose, a pharmacologically acceptable one can be used in the present invention. However, its preferable viscosity is 3 to 110 cps, more preferably 6 to 49 cps, most preferably 9 to 11 cps, when the viscosity of 5% ethylcellulose-toluene/ethanol (80/20) solution is measured by a viscosity test described in USP 23, NF18. For example, the preferable one is ETHOCELL (viscosity: 10) (trademark, Dow Chemical (US)).

The weight ratio of the macrolide compound and the water-insoluble polymer is preferably 1 : 0.01 to 1 : 10, more preferably 1 : 0.1 to 1 : 5; most preferably 1 0. 1 to 1 : 1, when the water-insoluble polymer is ethylcellulose; the weight ratio thereof is most preferably 1 : 0.5 to 1 : 5, when the water-insoluble polymer is a methacrylate copolymer.

The sustained-release formulation of the invention may further contain a water-soluble base; and more preferably, this added base is one of the following water-soluble polymers:

polyvinylpyrrolidone (PVP), cellulose polymer [hydroxypropylmethyl cellulose (HPMC), hydroxypropylmethyl cellulose phthalate, methyl cellulose (MC), carboxymethyl cellulose sodium (CMC-Na), hydroxyethyl cellulose, hy-
droxypropyl cellulose (HPC), etc.), pectin, cyclodextrins, galactomannan, polyethylene glycol (PEG) with a mean molecular weight of 4000 or more, gelatin, etc.

[0046] For use, furthermore, the water-soluble polymers are added individually or in a mixture of two or more thereof. A more preferable water-soluble base is cellulose polymer or PVP; and the most preferable water-soluble base is HPMC, PVP or a combination thereof. In particular, HPMC of a type with a low viscosity can exert a more desirable sustained-release effect, when used; an aqueous 2% solution of the type of HPMC is at a viscosity of 1 to 4,000 cps, preferably 1 to 50 cps, more preferably 1 to 15 cps, as measured at 20 °C by a viscometer of Brookfield type; in particular, HPMC 2910 at a viscosity of 3 cps (TC-5E, EW, Shin-estu Chemical Co., Ltd.) is preferable.

[0047] The weight ratio of the macrolide compound and such water-soluble base is preferably 1:0.05 to 1:2, more preferably 1:0.1 to 2:1, most preferably 1:0.2 to 1:0.4.

[0048] When preparing the solid dispersion composition of the present invention, the above water-insoluble base, may be usable singly or in combination with the water-soluble base. Since the water-insoluble base is adopted as the essential solid base in the present invention, suitable dissolution profile of the solid dispersion composition can be achieved by mixing a suitable amount of water-soluble base, such as water-soluble polymer (e.g., HPMC). If desired, other than the solid base described above, suitable excipients (lactose, etc.), binders, coloring agents, sweeteners, flavor, diluents, antioxidants (vitamin E, etc.) and lubricants (for example, synthetic aluminium silicate, magnesium stearate, calcium hydrogen phosphate, calcium stearate, talc, etc.) for common use, are added to prepare a solid dispersion composition.

[0049] Depending on the type of the solid base, additionally, the dissolution rate of the macrolide compound from the solid dispersion composition is sometimes too slow or the initial dissolution rate thereof is sometimes required to be elevated. In that case, the dissolution rate of the macrolide compound from the solid dispersion composition can be adjusted, by adding appropriate disintegrators [for example, cross carmelose sodium (CC-Na), carboxymethyl cellulose calcium (CM-Ca), lowly substituted hydroxypropyl cellulose (L-HPC), starch sodium glycolate, micro-fine crystal cellulose, cross povidone, etc.] or appropriate surfactants [for example, hardened polyoxyethylene castor oil, polyoxyethyl stearate 40, polysorbate 80, sodium lauryl sulfate, sucrose fatty acid ester (HLB is more than 10), etc] to the solid dispersion composition.

[0050] The particle size of the solid dispersion composition where the macrolide compound is present as an amorphous state in the solid base is preferably equal to or smaller than 500 μm. More preferably, the composition is of a particle size passing through a 350-μm, most preferably 250-μm sieve.

[0051] Furthermore, the solid dispersion composition of a macrolide compound comprised in the sustained-release formulation in accordance with the invention can be produced by methods described in EP 0 240 773 and WO 91/19495 and the like; the methods are more specifically described below.

[0052] The macrolide compound is dissolved in an organic solvent (for example, ethanol, dichloromethane or an aqueous mixture thereof, etc.), followed by addition of an appropriate amount of a solid base, and the resulting mixture is sufficiently dissolved or suspended together or is allowed to swell. Then, the mixture is sufficiently kneaded together. After removing the organic solvent from the mixture, the residue is dried and ground and is then subjected to size reduction, whereby a solid dispersion composition can be prepared, where the macrolide compound is present as an amorphous state in the solid base. During the kneading process, furthermore, lubricants such as calcium hydrogen phosphate, excipients such as lactose, and the like can further be added to the mixture, if necessary.

[0053] The sustained-release formulation comprising a macrolide compound in accordance with this invention can be manufactured by using a finely divided powder of the macrolide compound. The particle size control of the macrolide compound can be effected by means of milling machinery which is of routine use in pharmaceutical industry, such as a pin mill, hammer mill, jet mill, and dry or wet ball-mill, to name but a few examples. The macrolide compound fine powder should have a particle diameter distribution within the range of 0.1~50 μm, preferably 0.2~20 μm, and more preferably 0.5~10 μm, and/or a mean particle diameter of 0.2~20 μm, preferably 0.5~10 μm, and more preferably 1~5 μm.

[0054] The dispersion solid composition of the macrolide compound, thus produced by the above methods, can be used as such as a sustained-release formulation. Taking account of handleability as a formulation, dispersibility in water, and dispersibility after oral dosing, the composition is more preferably prepared as a sustained-release formulation. The sustained-release formulation, or the solid dispersion composition of macrolide compounds of the present invention can be preliminarily dispersed in water and juice, to be orally
given as a liquid formulation.

[0056] The effective dose of the macrolide compound varies, depending on the type of the compound, the age of a patient, his (her) disease, the severity thereof, or other factors. Generally, the effective ingredient is used at a dose of about 0.001 to 1,000 mg, preferably 0.01 to 500 mg, more preferably 0.1 to 100 mg per day for the therapeutic treatment of the disease; generally, a mean single dose is about 0.01 mg, 0.1 mg, 0.5 mg, 1 mg, 5 mg, 10 mg, 50 mg, 100 mg, 250 mg, and 500 mg.

[0057] After oral administration, the sustained-release formulation of the macrolide compound in accordance with the invention characteristically releases the macrolide compound in a sustained manner and the pharmaceutical activity maintains for a long period. In accordance with this invention, the frequency of administration of pharmaceutically active macrolide compounds can be decreased. More particularly, it has become possible to provide a macrolide-containing pharmaceutical formulation which may be administered only once a day. Furthermore, it is by now possible to provide a pharmaceutical composition which is free from the risk for undesired effects caused by a transiently excessive concentration and insures an expression of pharmacological efficacy over a sufficiently extended period of time.

[0058] The sustained-release formulation of the present invention is useful for treatment and/or prevention of the following diseases and conditions because of the pharmacological activities possessed by the said macrolide tricyclic compounds (I).

Rejection reactions by transplantation of organs or tissues such as the heart, kidney, liver, bone marrow, skin, cornea, lung, pancreas, small intestine, limb, muscle, nerve, intervertebral disc, trachea, myoblast, cartilage, etc.;
graft-versus-host reactions following bone marrow transplantation;
autoimmune diseases such as rheumatoid arthritis, systemic lupus erythematosus, Hashimoto's thyroiditis, multiple sclerosis, myasthenia gravis, type I diabetes, etc.;
and infections caused by pathogenic microorganisms (e.g. Aspergillus fumigatus, Fusarium oxysporum, Trichophyton asteroids, etc.);
Inflammatory or hyperproliferative skin diseases or cutaneous manifestations of immunologically-mediated diseases (e.g. psoriasis, atopic dermatitis, contact dermatitis, eczematoid dermatitis, seborrheic dermatitis, lichen planus, pemphigus, bullous pemphigoid, epidermolysis bullosa, urticaria, angioedema, vasculitides, erythema, dermal eosinophilia, lupus erythematosus, acne, and alopecia areata);
autoimmune diseases of the eye (e.g. keratoconjunctivitis, vernal conjunctivitis, uveitis associated with Behcet's disease, keratitis, herpetic keratitis, conical keratitis, corneal epithelial dystrophy, keratoleukoma, ocular pemphigus, Mooren's ulcer, scleritis, Graves' ophthalmopathy, Vogt-Koyanagi-Harada syndrome, keratoconjunctivitis sicca (dry eye), phlyctenule, iridocyclitis, sarcoidosis, endocrine ophthalmopathy, etc.);
reversible obstructive airways diseases [asthma (e.g. bronchial asthma, allergic asthma, intrinsic asthma, extrinsic asthma, and dust asthma), particularly chronic or invertebrate asthma (e.g. late asthma and airway hyper-responsiveness) bronchitis, etc.];
mucosal or vascular inflammations (e.g. gastric ulcer, ischemic or thrombotic vascular injury, ischemic bowel diseases, enteritis, necrotizing enterocolitis, intestinal damages associated with thermal burns, leukotriene B4-mediated diseases);
intestinal inflammations / allergies (e.g. coeliac diseases, proctitis, eosinophilic gastroenteritis, mastocytosis, Crohn's disease and ulcerative colitis);
food-related allergic diseases with symptomatic manifestation remote from the gastrointestinal tract (e.g. migraine, rhinitis and eczema);
renal diseases (e.g. intestinal nephritis, Goodpasture's syndrome, hemolytic uremic syndrome, and diabetic nephropathy);
nervous diseases (e.g. multiple myositis, Guillain-Barre syndrome, Meniere's disease, multiple neuritis, solitary neuritis, cerebral infarction, Alzheimer's disease, Parkinson's disease amyotrophic lateral sclerosis (ALS) and radiculopathy);
cerebral ischemic disease (e.g., head injury, hemorrhage in brain (e.g., subarachnoid hemorrhage, intracerebral hemorrhage), cerebral thrombosis, cerebral embolism, cardiac arrest, stroke, transient ischemic attack (TIA), hypertensive encephalopathy, cerebral infarction);
endocrine diseases (e.g. hyperthyroidism, and Basedow's disease);
hematic diseases (e.g. pure red cell aplasia, aplastic anemia, hypoplastic anemia, idiopathic thrombocytopenic purpura, autoimmune hemolytic anemia, agranulocytosis, pernicious anemia, megaloblastic anemia, and anerythroplasia);
bone diseases (e.g. osteoporosis);
respiratory diseases (e.g. sarcoidosis, pulmonary fibrosis, and idiopathic interstitial pneumonia);
skin diseases (e.g. dermatomyositis, leukoderma vulgaris, ichthyosis vulgaris, photosensitivity, and cutaneous T-cell lymphoma);
circulatory diseases (e.g. arteriosclerosis, atherosclerosis, aortitis syndrome, polyarteritis nodosa, and myocardiasis);
collagen diseases (e.g. scleroderma, Wegener's granuloma, and Sjogren's syndrome);
adiposis;
This invention further provides a dissolution test method for a solid formulation comprising macrolide compound, which uses a test solution containing a suitable amount of cellulose polymer. In general, the dissolution test for testing a release characteristic of a medicinally active ingredient dissolved from a solid formulation containing it is carried out in accordance with Dissolution Test, Method 2 (Paddle method, 50 rpm), JP XIII, or Dissolution Test shown in USP 23, NF18 or in European Pharmacopoeia (3rd edition). However, in conducting a dissolution test as to a formulation containing a small amount of a macrolide compound, the release of the macrolide compound based on the intrinsic content thereof may not reach 100% even after several hours. This is because, when the amount of the macrolide compound is small, adsorption of the macrolide compound on surfaces of the test vessel, filter, etc. will exert an influence of increased magnitude. After much investigation, the present inventors found that by adding a suitable amount of cellulose polymer (such as, HPMC, hydroxypropylcellulose phthalate, MC, CMC-Na, hydroxyethyl cellulose, hydroxypropyl cellulose(HPC), and so on) to the test solution and by, if necessary, adding phosphoric acid or the like to the test solution so as to bring its pH to not higher than 7 in order to avoid the adverse effect of the consequent increase in pH on the stability of the macrolide compound, the influence of adsorption of the macrolide compound on surfaces of the test apparatus can be inhibited to achieve a recovery rate of substantially 100%. Preferable cellulose polymer is hydroxypropyl cellulose or its equivalent, the preferable viscosity of which is such that when its 5.0 g is dissolved in 95 ml of water, and after centrifugation to remove the foam where necessary, the viscosity of the solution is measured with a rotary viscometer at 25±0.1°C, the solution shows a viscosity of 75-150 cps. For example, the hydroxypropyl cellulose with an average molecular weight of about 100,000 as available from Aldrich corresponds...
thereto.

The “suitable amount” of cellulose polymer to be added to the test solution is 0.001~0.1%, preferably 0.002~0.01%, and most preferably 0.005%, all based on the total amount of the test solution.

Dissolution Test, Method 2 (Paddle method, JP XIII, and dissolution test shown in USP 23, NF18 or in European Pharmacopoeia (3rd edition) are well-known methods for testing the release kinetics of the active ingredient from a solid pharmaceutical product. They are dissolution tests using the specified vessel, paddle and other hardware, with controlling quantity of test solution, temperature of test solution, rotational speed, and other conditions. Where necessary, the test is performed with the test solution adjusted to a suitable pH. In the present invention, pH is preferably not higher than 7. In the present invention, “Dissolution Test, Method 2 (Paddle method, 50 rpm, JP XIII)” means “Dissolution Test, Method 2 (Paddle method, JP XIII, which is carried out with stirring 50 revolutions per minute. The corresponding descriptions in JP XIII, USP 23 (NF18) and European Pharmacopoeia (3rd edition) is incorporated in this specification by reference.

The invention will now be described in the following examples. In the following examples, FK506 is admixed as its monohydrate when preparing compositions containing it, though its amount is expressed as the weight of FK506, not of its monohydrate.

Example 1 (Reference)

<table>
<thead>
<tr>
<th>FK506</th>
<th>HPMC 2910</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 mg</td>
<td>1.0 mg</td>
</tr>
<tr>
<td>total</td>
<td>2.0 mg</td>
</tr>
</tbody>
</table>

FK506 was dissolved in ethanol, and to the resulting solution was added HPMC 2910 for allowing FK506 to sufficiently swell. Thereafter, the mixture was kneaded together. The resulting kneaded mixture was transferred to a stainless tray, dried in vacuo, and ground with a coffee mill. Subsequently, the resulting powder was subjected to size reduction by the following processes, to prepare solid dispersion composition (hereinafter referred as SDC) 1-1 to 1-6).

1. The ground powder was passed through a 250-µm sieve, and a fraction of those remaining on the sieve is designated as SDC 1-1) (> 250 µm).
2. The fraction passing through the sieve at the process (1) was passed through a 180-µm sieve, and a fraction of those remaining on the sieve is designated as SDC 1-2) (180 - 250 µm).
3. The fraction passing through the sieve at the process (2) was passed through a 150-µm sieve, and a fraction of those remaining on the sieve is designated as SDC 1-3) (150 - 180 µm).
4. The fraction passing through the sieve at the process (3) was passed through a 106-µm sieve, and a fraction of those remaining on the sieve is designated as SDC 1-4) (106 - 150 µm).
5. The fraction passing through the sieve at the process (4) was passed through a 75-µm sieve, and a fraction of those remaining on the sieve is designated as SDC 1-5) (75 - 106 µm).
6. The fraction passing through the sieve at the process (5) is designated as SDC 1-6) (< 75 µm).

Example 2 (Reference)

The SDC 1-2), which was obtained in Example 1, was sufficiently mixed with lactose (58.0 mg), and the resulting mixture was encapsulated, to prepare a capsule.

Example 3 (Reference)

In a similar manner to that of Example 1, a ground powder of the following SDC of particle sizes of 180 to 250 µm was prepared.

<table>
<thead>
<tr>
<th>SDC</th>
<th>Macrolide compound</th>
<th>Water-soluble base</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-1)</td>
<td>FK506 (1.0 mg)</td>
<td>HPMC 2910 (0.3 mg)</td>
</tr>
<tr>
<td>3-2)</td>
<td>FK506 (1.0 mg)</td>
<td>HPMC 2910 (0.1 mg)</td>
</tr>
</tbody>
</table>

Furthermore, the SDC 3-1) was sufficiently mixed with lactose (58.7 mg), and the resulting mixture was en-
capsulated, to prepare capsule 3-1). The SDC 3-2) was sufficiently mixed with lactose (58.9 mg), and the resulting mixture was encapsulated to prepare capsule 3-2).

Example 4 (Reference)

[0070] In a similar manner to that for SDC 1-2) of Example 1, the following SDCs were prepared.

<table>
<thead>
<tr>
<th>SDC</th>
<th>Macrolide compound</th>
<th>Water-soluble base</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-1) (2.0 mg in total)</td>
<td>FK506 (1.0 mg)</td>
<td>MC (1.0 mg)</td>
</tr>
<tr>
<td>4-2) (2.0 mg in total)</td>
<td>FK506 (1.0 mg)</td>
<td>PVP (1.0 mg)</td>
</tr>
<tr>
<td>4-3) (2.0 mg in total)</td>
<td>FK506 (1.0 mg)</td>
<td>HPMC 2910 (1.0 mg)</td>
</tr>
<tr>
<td>4-4) (2.0 mg in total)</td>
<td>FK506 (1.0 mg)</td>
<td>HPC (1.0 mg)</td>
</tr>
<tr>
<td>4-5) (2.0 mg in total)</td>
<td>FK506 (1.0 mg)</td>
<td>PEG (1.0 mg)</td>
</tr>
<tr>
<td>4-6) (2.0 mg in total)</td>
<td>FK506 (1.0 mg)</td>
<td>HPMC 2910 (0.8 mg) PVP (0.2 mg)</td>
</tr>
</tbody>
</table>

[0071] In a similar manner to that of Example 2, lactose (at an appropriate amount) and magnesium stearate (0.6 mg) were added to the respective SDCs to prepare respective capsules, each of 60.0 mg in total.

Example 5 (Reference)

[0072] In a similar manner to that of the SDC 1-2) in Example 1, a SDC was prepared by using FK506 (1.0 mg) and HPMC 2910 (1.0 mg). In a similar manner to that of Example 2, thereafter, the following additives were respectively added to the SDC to prepare capsules 5-1) to 5-4), each of 60.0 mg in total.

<table>
<thead>
<tr>
<th>Capsule No.</th>
<th>Additive(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-1)</td>
<td>crystal cellulose</td>
</tr>
<tr>
<td></td>
<td>magnesium stearate</td>
</tr>
<tr>
<td></td>
<td>(appropriate amount)</td>
</tr>
<tr>
<td></td>
<td>(0.6 mg)</td>
</tr>
<tr>
<td>5-2)</td>
<td>calcium hydrogen phosphate</td>
</tr>
<tr>
<td></td>
<td>magnesium stearate</td>
</tr>
<tr>
<td></td>
<td>(appropriate amount)</td>
</tr>
<tr>
<td></td>
<td>(0.6 mg)</td>
</tr>
<tr>
<td>5-3)</td>
<td>lactose</td>
</tr>
<tr>
<td></td>
<td>L-HPC</td>
</tr>
<tr>
<td></td>
<td>magnesium stearate</td>
</tr>
<tr>
<td></td>
<td>(appropriate amount)</td>
</tr>
<tr>
<td></td>
<td>(3.0 mg)</td>
</tr>
<tr>
<td></td>
<td>(0.6 mg)</td>
</tr>
<tr>
<td>5-4)</td>
<td>corn starch</td>
</tr>
<tr>
<td></td>
<td>calcium stearate</td>
</tr>
<tr>
<td></td>
<td>(appropriate amount)</td>
</tr>
<tr>
<td></td>
<td>(0.6 mg)</td>
</tr>
</tbody>
</table>

Example 6 (Reference)

[0073]
FK506 was dissolved in ethanol, and to the resulting solution was added HPMC 2910 to allow to sufficiently swell. Subsequently, the mixture was kneaded together. The resulting kneaded substance was transferred onto a stainless tray, dried in vacuo, and ground with a coffee mill. Subsequently, the resulting powder was subjected to size reduction by the following processes, to prepare SDCs 6-1) to 6-6).

(1) The ground powder was passed through a 250-µm sieve, and a fraction of those remaining on the sieve is designated as SDC 6-1) (> 250 µm).
(2) The fraction passing through the sieve at the process (1) was passed through a 180-µm sieve, and a fraction of those remaining on the sieve is designated as SDC 6-2) (180 - 250 µm).
(3) The fraction passing through the sieve at the process (2) was passed through a 150-µm sieve, and a fraction of those remaining on the sieve is designated as SDC 6-3) (150 - 180 µm).
(4) The fraction passing through the sieve at the process (3) was passed through a 106-µm sieve, and a fraction of those remaining on the sieve is designated as SDC 6-4) (106 - 150 µm).
(5) The fraction passing through the sieve at the process (4) was passed through a 75-µm sieve, and a fraction of those remaining on the sieve is designated as SDC 6-5) (75 - 106 µm).
(6) The fraction passing through the sieve at the process (5) is designated as SDC 6-6).

Example 7 (Reference)

The SDC 6-4) (1.3 mg) which was obtained in Example 6 was mixed thoroughly with lactose (58.1 mg) and magnesium stearate (0.6 mg), and the resulting mixture was filled in capsules, which was defined as capsule 7.

Example 8 (Reference)

In a similar manner to that of Example 1, the following SDCs at particle sizes of 180-250 µm are prepared.

<table>
<thead>
<tr>
<th>SDCs</th>
<th>Macrolide compound</th>
<th>Water-soluble base</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-1)</td>
<td>ascomycin</td>
<td>HPMC 2910</td>
</tr>
<tr>
<td></td>
<td>(1.0 mg)</td>
<td>(0.3 mg)</td>
</tr>
<tr>
<td>8-2)</td>
<td>33-epi-chloro-33-desoxyascomycin</td>
<td>HPMC 2910</td>
</tr>
<tr>
<td></td>
<td>(1.0 mg)</td>
<td>(0.3 mg)</td>
</tr>
<tr>
<td>8-3)</td>
<td>40-O-(2-hydroxy)-ethyl-rapamycin</td>
<td>HPMC 2910</td>
</tr>
<tr>
<td></td>
<td>(1.0 mg)</td>
<td>(0.3 mg)</td>
</tr>
</tbody>
</table>

Example 9 (Reference)

In a similar manner to that of Example 7, each capsule is prepared by adding lactose (58.1 mg) and magnesium stearate (0.6 mg).

Example 9 (Reference)

<table>
<thead>
<tr>
<th>SDC 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>FK506</td>
</tr>
<tr>
<td>HPMC 2910</td>
</tr>
<tr>
<td>calcium hydrogen phosphate</td>
</tr>
<tr>
<td>total</td>
</tr>
</tbody>
</table>

Formulation 9

| SDC 9 | 16 g |
| lactose | qs |
| magnesium stearate | 7 g |
FK506 was dissolved in ethanol, and HPMC 2910 is added to and mixed sufficiently with the resulting solution, followed by further addition of calcium hydrogen phosphate. After drying in vacuo overnight, the resulting mixture was subjected to size reduction by using a speed mill and a roll granulator; the resulting powder was sieved with a sieve of 212 µm; a fraction of those passing through the sieve is designated as SDC 9. The SDC 9, lactose and magnesium stearate were mixed together, to prepare Formulation 9. The Formulation 9 was filled at 350 mg in No. 1 capsule and at 70 mg in No. 5 gelatin capsule, which were defined as Formulations A and B, respectively.

Example 10 (Reference)

FK506 was dissolved in ethanol, and HPMC 2910 was added to and mixed sufficiently with the resulting solution, followed by further addition of calcium hydrogen phosphate. After drying in vacuo overnight, the resulting mixture was subjected to size reduction by using a speed mill and a roll granulator; the resulting powder was sieved with a sieve of 212 µm; a fraction of those passing through the sieve is designated as SDC 9. The SDC 9, lactose and magnesium stearate were mixed together, to prepare Formulation 9. The Formulation 9 was filled at 350 mg in No. 1 capsule and at 70 mg in No. 5 gelatin capsule, which were defined as Formulations A and B, respectively.

Example 11 (Reference)

FK506 was dissolved in ethanol, and HPMC 2910 was added to and mixed sufficiently with the resulting solution, followed by further addition of calcium hydrogen phosphate. After the resulting mixture was dried in vacuo overnight, the mixture was subjected to size reduction by using a speed mill and a roll granulator; the resulting powder was sieved
with a sieve of 250 µm and a sieve of 180 µm; a fraction of 180 - 250 µm is defined as SDC 11. The SDC 11, lactose and magnesium stearate were mixed together, to prepare Formulation 11. The Formulation 11 was filled at 350 mg in No. 1 capsule and at 70 mg in No. 5 gelatin capsule, which were defined as Formulations C and D, respectively.

Example 12

[0083]

<table>
<thead>
<tr>
<th></th>
<th>SDC 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>FK506</td>
<td>2 g</td>
</tr>
<tr>
<td>glycerin monostearate</td>
<td>98 g</td>
</tr>
<tr>
<td>HPMC 2910</td>
<td>20 g</td>
</tr>
<tr>
<td>total</td>
<td>120 g</td>
</tr>
</tbody>
</table>

Formulation 12

<table>
<thead>
<tr>
<th></th>
<th>SDC 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>magnesium stearate</td>
<td>1.2 g</td>
</tr>
<tr>
<td>total</td>
<td>121.2 g</td>
</tr>
</tbody>
</table>

[0084] Glycerin monostearate was heated and melt at 80 °C, to which was added FK506 under agitation to dissolve FK506 therein. To the resulting mixture was added HPMC 2910 for sufficient mixing, and the resulting mixture was then transferred to a tray to stand alone for spontaneous cooling. The solid substance obtained by cooling was ground with a coffee mill and was then sieved with a sieve of 500 µm. A fraction of those passing through the sieve was defined as SDC 12. The SDC 12 was mixed with magnesium stearate, to prepare Formulation 12, which is then filled at 60.6 mg in No. 5 capsule. The resulting capsule is defined as Formulation E.

Example 13

[0085]

<table>
<thead>
<tr>
<th></th>
<th>SDC 13</th>
</tr>
</thead>
<tbody>
<tr>
<td>FK506</td>
<td>2 g</td>
</tr>
<tr>
<td>Aminoalkyl methacrylate copolymer (Eudragit RL)</td>
<td>6 g</td>
</tr>
<tr>
<td>calcium hydrogen phosphate</td>
<td>2 g</td>
</tr>
<tr>
<td>total</td>
<td>10 g</td>
</tr>
</tbody>
</table>

Formulation 13

<table>
<thead>
<tr>
<th></th>
<th>SDC 13</th>
</tr>
</thead>
<tbody>
<tr>
<td>lactose</td>
<td>10 g</td>
</tr>
<tr>
<td>total</td>
<td>140 g</td>
</tr>
</tbody>
</table>

[0086] In ethanol were dissolved FK506 and aminoalkyl methacrylate copolymer, followed by addition of calcium hydrogen phosphate, and the resulting mixture was sufficiently mixed together. The mixture was dried in vacuo overnight, ground in a mortar, and graded by using sieves of 150 µm and 106 µm, to prepare a fraction of 106 - 150 µm as SDC 13. The SDC 13 was mixed with lactose and prepared as Formulation 13, and was then filled at 70 mg in No. 5 gelatin capsule to be prepared as Formulation F.
Example 14

[0087] In a similar manner to that of Example 13, SDC 14 at particle sizes of 106 - 150 µm and Formulation 14 were prepared. And then Formulation 14 was filled at 70 mg in No. 5 gelatin capsule to be prepared as Formulation G.

<table>
<thead>
<tr>
<th>SDC 14</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FK506</td>
<td>2 g</td>
</tr>
<tr>
<td>Aminoalkyl methacrylate copolymer (Eudragit RL)</td>
<td>4.6 g</td>
</tr>
<tr>
<td>Aminoalkyl methacrylate copolymer (Eudragit RS)</td>
<td>1.4 g</td>
</tr>
<tr>
<td>calcium hydrogen phosphate</td>
<td>2 g</td>
</tr>
<tr>
<td><strong>total</strong></td>
<td><strong>10 g</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Formulation 14</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDC 14</td>
</tr>
<tr>
<td>lactose</td>
</tr>
<tr>
<td><strong>total</strong></td>
</tr>
</tbody>
</table>

Example 15

[0089] In a similar manner to that of Example 13, SDC 15 at particle sizes of 106 - 150 µm and Formulation 15 were prepared. And then Formulation 15 was filled at 70 mg in No. 5 gelatin capsule to be prepared as Formulation H.

<table>
<thead>
<tr>
<th>SDC 15</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FK506</td>
<td>2 g</td>
</tr>
<tr>
<td>Aminoalkyl methacrylate copolymer (Eudragit RL)</td>
<td>3 g</td>
</tr>
<tr>
<td>Aminoalkyl methacrylate copolymer (Eudragit RS)</td>
<td>3 g</td>
</tr>
<tr>
<td>calcium hydrogen phosphate</td>
<td>2 g</td>
</tr>
<tr>
<td><strong>total</strong></td>
<td><strong>10 g</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Formulation 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDC 15</td>
</tr>
<tr>
<td>lactose</td>
</tr>
<tr>
<td><strong>total</strong></td>
</tr>
</tbody>
</table>

Example 16

[0090] In a similar manner to that of Example 13, SDC 15 at particle sizes of 106 - 150 µm and Formulation 15 were prepared. And then Formulation 15 was filled at 70 mg in No. 5 gelatin capsule to be prepared as Formulation H.

<table>
<thead>
<tr>
<th>SDC 16</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FK506</td>
<td>2 g</td>
</tr>
<tr>
<td>Ethylcellulose</td>
<td>0.4 g</td>
</tr>
<tr>
<td>lactose</td>
<td>6 g</td>
</tr>
<tr>
<td><strong>total</strong></td>
<td><strong>8.4 g</strong></td>
</tr>
</tbody>
</table>
In ethanol was dissolved FK506 and ethylcellulose, followed by addition of lactose, and the resulting mixture was sufficiently mixed together. The mixture was dried in vacuo overnight, ground in a mortar, and graded by using sieves of 150 µm and 106 µm, to prepare a fraction of 106 - 150 µm as SDC 16. The SDC 16 was mixed with lactose and prepared as Formulation 16, and was then filled at 70 mg in No. 5 gelatin capsule to be prepared as Formulation I.

Example 17

In a similar manner to that of Example 16, SDC 17 at particle sizes of 106 - 150 µm and Formulation 17 were prepared. And then Formulation 17 was filled at 70 mg in No. 5 gelatin capsule to be prepared as Formulation J.

Example 18

In a similar manner to that of Example 16, SDC 18 at particle sizes of 106 - 150 µm and Formulation 18 were prepared. And then Formulation 18 was filled at 70 mg in No. 5 gelatin capsule to be prepared as Formulation K.
Example 19

[0096]

<table>
<thead>
<tr>
<th>SDC 19</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FK506</td>
<td>2 g</td>
<td></td>
</tr>
<tr>
<td>Ethylcellulose</td>
<td>0.6 g</td>
<td></td>
</tr>
<tr>
<td>HPMC 2910</td>
<td>0.6 g</td>
<td></td>
</tr>
<tr>
<td>lactose</td>
<td>6 g</td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>9.2 g</td>
<td></td>
</tr>
</tbody>
</table>

[0097] In a similar manner to that of Example 16, SDC 19 at particle sizes of 106-150 µm and Formulation 19 were prepared. And then Formulation 19 was filled at 70 mg in No. 5 gelatin capsule to be prepared as Formulation L.

Example 20

[0098]

<table>
<thead>
<tr>
<th>SDC 20</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FK506</td>
<td>10 g</td>
<td></td>
</tr>
<tr>
<td>Ethylcellulose</td>
<td>3 g</td>
<td></td>
</tr>
<tr>
<td>HPMC 2910</td>
<td>3 g</td>
<td></td>
</tr>
<tr>
<td>lactose</td>
<td>50 g</td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>66 g</td>
<td></td>
</tr>
</tbody>
</table>

[0099] FK506 was dissolved in ethanol, and ethylcellulose was added to and was solved. And HPMC 2910 and lactose were mixed sufficiently with the resulting solution. After drying in vacuo overnight, the resulting mixture was subjected to size reduction by using a power mill and a roll granulator; the resulting powder was sieved with a sieve of 250 µm; a fraction of those passing through the sieve is designated as SDC 20. The SDC 20, lactose and magnesium stearate were mixed together, to prepare Formulation 20. The Formulation 20 was filled at 350 mg in No. 1 capsule and at 70 mg in No. 5 gelatin capsule, which were defined as Formulations M and N, respectively.

Example 21

[0100]

<table>
<thead>
<tr>
<th>SDC 21</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FK506</td>
<td>10 g</td>
</tr>
</tbody>
</table>
In a similar manner to that of Example 20, a fraction of those passing through the sieve 212 µm was designated as SDC 21 and Formulation 21 were prepared. And then Formulation 21 was filled at 350 mg in No. 1 gelatin capsule and at 70 mg in No. 5 gelatin capsule to be prepared as Formulation O and P, respectively.

Example 22

In ethanol/acetone (1/1) was dissolved FK506. After heating its solution at 75°C, sucrose fatty acid ester was added to be solved and then cooled at room temperature. The mixture was dried in vacuo overnight, ground in a mortar, and graded by using sieves of 150 µm and 106 µm, to prepare a fraction of 106 - 150 µm as SDC 22. The SDC 22 was mixed with lactose and prepared as Formulation 22, and was then filled at 70 mg in No. 5 gelatin capsule to be prepared as Formulation Q.

Example 23

(continued)

SDC 21

| Ethylcellulose | 3 g |
| HPMC 2910      | 3 g |
| lactose        | 20 g |
| **total**      | 36 g |

| SDC 21          | 36 g |
| lactose         | qs   |
| magnesium stearate | 7 g |
| **total**       | 700 g |

**Formulation 21**

| SDC 21 | 36 g |
| lactose | qs   |
| magnesium stearate | 7 g |
| **total** | 700 g |

In ethanol/acetone (1/1) was dissolved FK506. After heating its solution at 75°C, sucrose fatty acid ester was added to be solved and then cooled at room temperature. The mixture was dried in vacuo overnight, ground in a mortar, and graded by using sieves of 150 µm and 106 µm, to prepare a fraction of 106 - 150 µm as SDC 22. The SDC 22 was mixed with lactose and prepared as Formulation 22, and was then filled at 70 mg in No. 5 gelatin capsule to be prepared as Formulation Q.

Example 23

(continued)

SDC 23

| FK506 | 1 g |
| sucrose fatty acid ester (HLB=6) (DK ester F-50) | 1 g |
| sucrose fatty acid ester (HLB=2) (DK ester F-20W) | 0.75 g |
| **total** | 2 g |
In a similar manner to that of Example 22, SDC 13 at particle sizes of 106 - 150 µm and Formulation 23 were prepared. And then Formulation 23 was filled at 70 mg in No. 5 gelatin capsule to be prepared as Formulation R.

Example 24

In a similar manner to that of Example 22, SDC 24 at particle sizes of 106 - 150 µm and Formulation 24 were prepared. And then Formulation 24 was filled at 70 mg in No. 5 gelatin capsule to be prepared as Formulation S.

Example 25

In a similar manner to that of Example 22, SDC 25 at particle sizes of 106 - 150 µm and Formulation 25 were prepared. And then Formulation 25 was filled at 70 mg in No. 5 gelatin capsule to be prepared as Formulation T.
Example 26

[0110]

<table>
<thead>
<tr>
<th>SDC 26</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FK506</td>
<td>1 g</td>
</tr>
<tr>
<td>Sucrose fatty acid ester (HLB=1) (DK ester F-10)</td>
<td>1 g</td>
</tr>
<tr>
<td>Lactose</td>
<td>5 g</td>
</tr>
<tr>
<td>total</td>
<td>7 g</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Formulation 26</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SDC 26</td>
<td>7 g</td>
</tr>
<tr>
<td>Lactose</td>
<td>63 g</td>
</tr>
<tr>
<td>total</td>
<td>70 g</td>
</tr>
</tbody>
</table>

[0111] In a similar manner to that of Example 22, SDC 26 at particle sizes of 106 - 150 µm and Formulation 26 were prepared. And then Formulation 26 was filled at 70 mg in No. 5 gelatin capsule to be prepared as Formulation U.

Example 27

[0112]

<table>
<thead>
<tr>
<th>SDC 27</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FK506</td>
<td>1 g</td>
</tr>
<tr>
<td>Tetracylglycerine trifatty acid ester</td>
<td>30 g</td>
</tr>
<tr>
<td>Lactose</td>
<td>15 g</td>
</tr>
<tr>
<td>total</td>
<td>46 g</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Formulation 27</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SDC 27</td>
<td>46 g</td>
</tr>
<tr>
<td>Lactose</td>
<td>24 g</td>
</tr>
<tr>
<td>total</td>
<td>70 g</td>
</tr>
</tbody>
</table>

[0113] In tetracylglycerine trifatty acid ester melted by heating at 80 °C was added and solved FK506 with mixing. Lactose was added thereto, mixed and then cooled spontaneously in a tray. The resulting solid substance was ground by a coffee mill, and graded by using sieves of 150 µm and 106 µm, to prepare a fraction of 106 - 150 µm as SDC 27. The SDC 27 was mixed with lactose and prepared as Formulation 27, and then Formulation 27 was filled at 70 mg in No. 5 gelatin capsule to be prepared as Formulation V.

Example 28

[0114]

<table>
<thead>
<tr>
<th>SDC 28</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FK506</td>
<td>1 g</td>
</tr>
<tr>
<td>Tetracylglycerine trifatty acid ester</td>
<td>30 g</td>
</tr>
<tr>
<td>Polysorbate</td>
<td>0.3 g</td>
</tr>
<tr>
<td>total</td>
<td>31.3 g</td>
</tr>
</tbody>
</table>
In a similar manner to that of Example 27, SDC 28 at particle sizes of 106-150 \( \mu \)m and Formulation 28 were prepared. And then Formulation 28 was filled at 70 mg in No. 5 gelatin capsule to be prepared as Formulation W.

Example 29

Ethanol was added to tetraglycerine trifatty acid ester. The resulting mixture was melted by heating at 40° C and FK506 was added and melted with mixing. Lactose was added thereto, mixed and then cooled spontaneously in a tray. The resulting solid substance was ground by a coffee mill, dried in vacuo overnight and graded by using sieves of 150 \( \mu \)m and 106 \( \mu \)m, to prepare a fraction of 106 - 150 \( \mu \)m as SDC 29. The SDC 29 was mixed with lactose and prepared as Formulation 29, and then Formulation 29 was filled at 70 mg in No. 5 gelatin capsule to be prepared as Formulation X.

Example 30 (Reference)

FK506 crystal was ground by a jet mill and was mixed with lactose and magnesium stearate to prepare Formulation 30. Then Formulation 30 was filled at 60 mg in No. 5 gelatin capsule to be prepared as Formulation Z. The range of particle size of FK506 fine powder ground by a jet mill was 1-10 \( \mu \)m and its mean particle size was about 3 \( \mu \)m.
Example 31 (Reference)

Dissolution test

Test sample:

[0120]

(1) Formulations A and C, which were prepared in Examples mentioned before.

(2) Control formulation (rapid-release formulation), which is 1 mg capsule formulation comprising the following ingredients. It is prepared, in a similar manner to that of Examples 1 and 2 of WO 91/19495, by mixing ingredients (e) and (f) with the solid dispersion composition composed of the following ingredients (a) to (d), and by being encapsulated.

<table>
<thead>
<tr>
<th></th>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>tacrolimus (FK506)</td>
<td>1 mg</td>
</tr>
<tr>
<td>(b)</td>
<td>hydroxypropylmethyl cellulose</td>
<td>1 mg</td>
</tr>
<tr>
<td>(c)</td>
<td>lactose</td>
<td>2 mg</td>
</tr>
<tr>
<td>(d)</td>
<td>cross carmelose sodium</td>
<td>1 mg</td>
</tr>
<tr>
<td>(e)</td>
<td>lactose</td>
<td>59.35 mg</td>
</tr>
<tr>
<td>(f)</td>
<td>magnesium stearate</td>
<td>0.65 mg</td>
</tr>
</tbody>
</table>

Test method:

[0121] According to the Japanese Pharmacopoeia, the 13-edition, Dissolution Test, No. 2 (Paddle method, 50 rpm) using an aqueous 0.005 % hydroxypropyl cellulose solution, adjusted to pH 4.5 as a test solution, a test was conducted. The obtained data were shown in the following.

<table>
<thead>
<tr>
<th>Time (hr)</th>
<th>Formulation A (%)</th>
<th>Time (hr)</th>
<th>Formulation C (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.5</td>
<td>17.4</td>
<td>1</td>
<td>12.1</td>
</tr>
<tr>
<td>1</td>
<td>35.6</td>
<td>2</td>
<td>30.9</td>
</tr>
<tr>
<td>2</td>
<td>57.6</td>
<td>4</td>
<td>55.9</td>
</tr>
<tr>
<td>3</td>
<td>71.9</td>
<td>6</td>
<td>71.3</td>
</tr>
<tr>
<td>4</td>
<td>80.9</td>
<td>8</td>
<td>81.6</td>
</tr>
<tr>
<td>6</td>
<td>89.7</td>
<td>10</td>
<td>87.0</td>
</tr>
<tr>
<td>9</td>
<td>95.2</td>
<td>12</td>
<td>90.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time (hr)</th>
<th>Control (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.17</td>
<td>30.1</td>
</tr>
<tr>
<td>0.5</td>
<td>68.4</td>
</tr>
<tr>
<td>1</td>
<td>92.8</td>
</tr>
<tr>
<td>2</td>
<td>100.1</td>
</tr>
</tbody>
</table>

Example 32

[0122] In a similar manner to that of Example 31, dissolution test was carried out. And thereby various parameters in Weibull function and T63.2% were obtained by calculation.
Example 33 (Reference)

Oral absorbability

Test sample:

(1) Formulations B and D, which were prepared in the Examples mentioned before.
(2) Control formulation (the same as the control in Example 31)

Test Method:

The test samples were orally given to 6 cynomologus monkeys (at 1 mg/monkey as an FK506 dose), to assay the blood FK506 concentration after administration. Seventeen hours prior to the administration, feeds were withdrawn from a feed table for cynomologus monkeys of body weights around 6 kg. Then, the animals were starved until 12 hours passed after the administration. Water was fed ad libitum prior to the initiation of the test throughout the administration of the test samples and thereafter. At the dosing, water (20 ml) was simultaneously given to the animals. At
predetermined intervals after dosing, 1 ml of blood was drawn from the forearm vein by using a sterile syringe into a plastic tube containing heparin and stored at about -80 °C until the assay of the drug concentration started. The whole blood drug concentration of FK506 was assayed by the FK506-specific enzyme immunoassay (EIA) known in JP-A-1-92659. The disclosure thereof is cited herein and encompassed within the description of the specification.

<table>
<thead>
<tr>
<th>Time (hr)</th>
<th>Formulation B</th>
<th>Formulation D</th>
<th>control</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0.5</td>
<td>0.44</td>
<td>0.28</td>
<td>0.91</td>
</tr>
<tr>
<td>1</td>
<td>2.59</td>
<td>1.03</td>
<td>3.02</td>
</tr>
<tr>
<td>2</td>
<td>4.26</td>
<td>2.27</td>
<td>7.13</td>
</tr>
<tr>
<td>4</td>
<td>3.89</td>
<td>3.14</td>
<td>3.27</td>
</tr>
<tr>
<td>6</td>
<td>3.48</td>
<td>4.42</td>
<td>3.85</td>
</tr>
<tr>
<td>8</td>
<td>3.47</td>
<td>4.12</td>
<td>2.63</td>
</tr>
<tr>
<td>10</td>
<td>3.70</td>
<td>4.06</td>
<td>2.48</td>
</tr>
<tr>
<td>12</td>
<td>3.73</td>
<td>4.10</td>
<td>2.51</td>
</tr>
<tr>
<td>14</td>
<td>3.85</td>
<td>4.13</td>
<td>2.27</td>
</tr>
<tr>
<td>16</td>
<td>3.60</td>
<td>4.75</td>
<td>2.20</td>
</tr>
<tr>
<td>18</td>
<td>2.96</td>
<td>3.95</td>
<td>1.76</td>
</tr>
<tr>
<td>24</td>
<td>2.21</td>
<td>2.57</td>
<td>1.32</td>
</tr>
</tbody>
</table>

[0126] The maximum blood concentration (Cmax) is defined as the maximum value of the whole blood drug. Tmax is the time required for reaching the maximum blood concentration. MRT is defined as the mean retention time. The area under the blood concentration-time curve (AUC) was calculated by the trapezoid method. And as an indicator of the variation of oral absorbability, CV (standard deviation/mean in %) was calculated.

<table>
<thead>
<tr>
<th>Test Samples</th>
<th>Cmax (ng/mL)</th>
<th>Tmax (hr)</th>
<th>MRT (hr)</th>
<th>AUC0-72hr (ng·hr/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Formulation No.)</td>
<td>(C.V.%)</td>
<td>(C.V.%)</td>
<td>(C.V.%)</td>
<td>(C.V.%)</td>
</tr>
<tr>
<td>B</td>
<td>5.51±1.02</td>
<td>8.2±2.9</td>
<td>21.1±0.5</td>
<td>126.3±22.2</td>
</tr>
<tr>
<td></td>
<td>(45.4)</td>
<td>(87.8)</td>
<td>(5.5)</td>
<td>(43.1)</td>
</tr>
<tr>
<td>D</td>
<td>5.48±0.94</td>
<td>10.0±2.7</td>
<td>22.6±1.0</td>
<td>144.3±21.0</td>
</tr>
<tr>
<td></td>
<td>(41.8)</td>
<td>(66.9)</td>
<td>(11.2)</td>
<td>(35.7)</td>
</tr>
<tr>
<td>Control</td>
<td>8.41±1.46</td>
<td>3.3±0.8</td>
<td>17.6±0.9</td>
<td>91.1±20.4</td>
</tr>
<tr>
<td></td>
<td>(42.6)</td>
<td>(62.2)</td>
<td>(12.7)</td>
<td>(54.9)</td>
</tr>
</tbody>
</table>

Example 34

[0127] According to a similar manner to that of Example 33, the oral absorbability of the various formulations of the present invention was carried out.

<table>
<thead>
<tr>
<th>Test samples</th>
<th>Cmax (ng/mL)</th>
<th>Tmax (hr)</th>
<th>MRT (hr)</th>
<th>AUC0-72hr (ng·hr/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Formulation No.)</td>
<td>[CV%]</td>
<td>[CV%]</td>
<td>[CV%]</td>
<td>[CV%]</td>
</tr>
<tr>
<td>E</td>
<td>9.36±1.08</td>
<td>6.3±1.7</td>
<td>20.0±0.4</td>
<td>186.6±18.5</td>
</tr>
<tr>
<td></td>
<td>[28.4]</td>
<td>[67.5]</td>
<td>[5.1]</td>
<td>[24.3]</td>
</tr>
<tr>
<td>L</td>
<td>6.16±0.57</td>
<td>4.3±1.1</td>
<td>19.3±0.5</td>
<td>135.5±17.7</td>
</tr>
<tr>
<td></td>
<td>[22.6]</td>
<td>[61.4]</td>
<td>[6.9]</td>
<td>[31.9]</td>
</tr>
<tr>
<td>Q</td>
<td>4.70±0.39</td>
<td>5.0±1.7</td>
<td>21.4±1.6</td>
<td>122.6±10.2</td>
</tr>
</tbody>
</table>

25
The above results show that the formulations adopted in the above experiments, after oral administration, have smaller Cmax, sufficiently prolonged Tmax and MRT than those of the rapid-release formulation (control). And compared with the rapid-release formulation, AUC shown by the above formulations are almost the same or more. Or the above sustained-release formulations have small variations in individuals of Cmax and/or AUC, compared with a rapid-release formulation.

In accordance with the invention of the present application, the small variation in individuals of the maximum blood concentration or area under the blood concentration time curve of the macrolide compound after oral dosing, compared with a rapid release formulation thereof can be determined, by using an indicator of the variation of the blood absorbability of the macrolide compound, namely standard deviation/mean (CV in %) of the maximum blood concentration or the area under the blood concentration time curve. The term "small variation" means a small CV value thereof; more specifically, the term means that the CV value is smaller than that of a rapid release formulation as described above.

The disclosure of the patents, patent application and references cited herein in the application is encompassed within the description of the specification.

Claims

1. A sustained-release formulation of a macrolide compound, wherein the time (T63.2%) required for 63.2 % of the maximum amount of macrolide compound to be dissolved is 0.7 to 15 hours, as measured according to the Japanese Pharmacopoeia, the 13-th edition, Dissolution Test, No. 2 (Paddle method, 50 rpm) using a test solution which is an aqueous 0.005 % hydroxypropyl cellulose solution adjusted to pH 4.5, in which the macrolide compound is a tricyclic compound represented by the general formula (I) and a pharmaceutically acceptable salt thereof, wherein each of adjacent pairs of R¹ and R², R³ and R⁴, R⁵ and R⁶ independently
(a) is two adjacent hydrogen atoms, but R² may also be an alkyl group or
(b) may form another bond formed between the carbon atoms to which they are attached;

\[ R^7 \]

\[ R^8 \text{ and } R^9 \]

\[ R^{10} \]

\[ X \]

\[ Y \]

\[ R^{11} \text{ and } R^{12} \]

\[ R^{13}, R^{14}, R^{15}, R^{16}, R^{17}, R^{18}, R^{19}, R^{22} \text{ and } R^{23} \]

\[ R^{24} \]

\[ n \]

2. The sustained-release formulation in Claim 1, wherein the water-insoluble base is a water-insoluble polymer,

3. The sustained-release formulation in Claim 1, in which the solid dispersion composition is characterized by

   (1) lactose or calcium hydrogen phosphate being contained as an excipient and/or lubricant,
   (2) no disintegrator being contained, and
   (3) the particle size of said solid dispersion composition being equal to or smaller than 350 µm.

4. The sustained-release formulation in Claim 2, in which the solid dispersion composition is characterized by the water-insoluble polymer being present in an amount of 0.1 - 5 to the compound (I) (1.0) by weight.

5. The sustained-release formulation in Claim 2, in which the water-insoluble polymer is ethylcellulose or methacrylate copolymer.

6. The sustained-release formulation in Claim 5, in which the water-insoluble polymer is ethylcellulose.

7. The sustained-release formulation in Claim 2, in which a water-soluble polymer is mixed with the water-insoluble polymer.

8. The sustained-release formulation in Claim 7, in which the water-soluble polymer is hydroxypropylmethyl cellulose.
9. The sustained-release formulation in Claim 8, in which the solid dispersion composition is characterized by
   (1) the macrolide compound (I) is present as an amorphous state in a mixture of ethylcellulose and hydroxy-
       propylmethyl cellulose,
   (2) lactose is contained as an excipient,
   (3) the particle size of said solid dispersion composition is equal to or smaller than 250 µm.

10. The sustained-release formulation in Claim 9, in which the weight ratio of the compound (I) to hydroxypropylmethyl-
    cellulose is 1 to 0.2 - 0.4.

11. The sustained-release formulation in Claim 1, in which the water-insoluble base is wax.

12. The sustained-release formulation in Claim 11, in which the wax is glycerin monostearate, polyglycerin fatty acid
    ester or sucrose fatty acid ester.

13. The sustained-release formulation in Claim 11 or 12, in which the solid dispersion composition is characterized by
   (1) lactose or calcium hydrogen phosphate is contained as an excipient,
   (2) any disintegrators are not contained, and
   (3) the particle size of said solid dispersion composition is equal to or smaller than 350 µm.

14. The sustained-release formulation in Claim 12, which comprises a solid dispersion composition which is characterized by
    the compound (I) being present as an amorphous state in sucrose fatty acid ester, in an amount of
    0.2-20 to the compound (I) (1.0) by weight ratio.

15. The sustained-release formulation in Claim 12, which comprises a solid dispersion composition which is characterized by
    the compound (I) being present as an amorphous state in glycerin monostearate, in an amount of
    10 - 100 to the compound (I) (1.0) by weight ratio.

16. The sustained-release formulation in Claim 12, which comprises a solid dispersion composition which is characterized by
    the compound (I) being present as an amorphous state in polyglycerin fatty acid ester, in an amount of
    0.1-100 to the compound (I) (1.0) by weight ratio.

17. The sustained-release formulation in Claim 1, in which the compounds (I) are the ones, wherein each of adjacent
    pairs of R³ and R⁴ or R⁵ and R⁶ independently form another bond formed between the carbon atoms to which they
    are attached; each of R⁸ and R³² is independently a hydrogen atom:

   R⁹ is a hydroxy group;
   R¹⁰ is a methyl group, an ethyl group, a propyl group or an allyl group;
   X is a (hydrogen atom and a hydroxyl atom) or an oxo group; Y is an oxo group;
   each of R¹⁴, R¹⁵, R¹⁶, R¹⁷, R¹⁸, R¹⁹ and R²² is a methyl group;
   R²⁴ is a 3-R²⁰-4-R²¹-cyclohexyl group,
   in which R²⁰ is hydroxy, an alkoxyl group, an oxo group, or a -OCH₂OCH₂CH₂OCH₃ group, and
   R²¹ is hydroxy, -OCN, an alkoxyl group, a heteroaryloxy which may be substituted by suitable substituents, a
   -OCH₂OCH₂CH₂OCH₃ group, a protected hydroxy group, chloro, bromo, iodo, aminoxalylx, an azido group, p-tolyloxythiocarbonyloxy, or R²⁵R²⁶CHCOO-,
   in which R²⁵ is optionally protected hydroxy or protected amino, and R²⁶ is hydrogen or methyl, or
   R²⁶ and R²¹ together form an oxygen atom in an epoxide ring; and
   n is an integer of 1 or 2.

18. The sustained-release formulation in any of Claims 1 to 17, in which the compound (I) is tacrolimus or its hydrate.

19. The sustained-release formulation in any of Claims 1 to 18, which is in a form of powder, fine powder, granule,
    tablet or capsule.

20. The sustained-release formulation in Claim 1, in which the time (T₆₃.₂%) is 1.0 to 12 hours.

21. The sustained-release formulation in Claim 1, in which the time (T₆₃.₂%) is 1.3 to 8.2 hours.
22. The sustained-release formulation in Claim 1, in which the time (T63.2%) is 2 to 5 hours.

23. A sustained-release formulation comprising a solid dispersion composition which is characterized by

   (1) tacrolimus or its hydrate being present as an amorphous state in a mixture of ethylcellulose and hydroxy-
   propylmethyl cellulose in amount of 0.1 to 5 and 0.2 to 0.4 respectively to tacrolimus or its hydrate (1,0) by
   weight ratio,
   (2) lactose is contained as an excipient,
   (3) the particle size of said solid dispersion composition is equal to or smaller than 250 µm.

24. The sustained-release formulation in Claim 23, in which the amount of ethylcellulose is 0.1 - 1 to tacrolimus (1.0) by weight ratio.

25. The sustained-release formulation in Claim 23, in which the amount of lactose is 2, 3 or 5 to tacrolimus (1.0) by weight ratio.

26. The sustained-release formulation in Claim 23, in which any disintegrators are not contained in the solid dispersion composition.

27. The sustained-release formulation in Claim 23, in which the particle size of said solid dispersion composition is equal to or smaller than 212 µm.

28. A sustained-release formulation comprising a solid dispersion composition which is characterized by

   (1) tacrolimus or its hydrate being present as an amorphous state in a mixture of ethylcellulose and hydroxy-
   propylmethyl cellulose in an amount of 0.3 and 0.3 respectively to tacrolimus or its hydrate (1,0) by weight ratio,
   (2) lactose is contained as an excipient,
   (3) the particle size of said solid dispersion composition is equal to or smaller than 212 µm.

29. The sustained-release formulation in any of Claims 23 to 26, which is in a form of powder, fine powder, granule, tablet or capsule.

Patentansprüche

1. Makrolid-Formulierung mit verzögter Freisetzung, wobei die Zeit (T 63,2 %), die für das Lösen von 63,2 % der maximalen Menge der zu lösenden Makrolidverbindung erforderlich ist, 0, 7 bis 15 Stunden beträgt gemäß Messung nach der japanischen Pharmacopoeia, 13. Ausgabe, Lösungstest, Nr. 2 (Paddle-Verfahren, 50 Upm) unter Verwendung einer Testlösung, die eine auf einen pH von 4,5 eingestellte, wässrige, 0,005 % Hydroxypropylcellulose-Lösung ist, und wobei die Makrolidverbindung eine tricyclische Verbindung, die durch die allgemeine Formel (I) dargestellt ist, und ein pharmazeutisch akzeptables Salz davon ist,
wobei jedes der benachbarten Paare von R' und R², R³ und R⁴ sowie R⁵ und R⁶ unabhängig voneinander

(a) zwei benachbarte Wasserstoffatome sind, wobei aber R² auch eine Alkylgruppe sein kann, oder
(b) eine andere Bindung bilden können, die zwischen den Kohlenstoffatomen ausgebildet ist, mit denen sie verbunden sind;

R⁷ ein Wasserstoffatom, eine Hydroxygruppe, eine geschützte Hydroxygruppe, eine Alkoxygruppe oder eine Oxogruppe zusammen mit R¹ ist;
R⁸ und R⁹ unabhängig voneinander ein Wasserstoffatom oder eine Hydroxygruppe sind;
R¹⁰ ein Wasserstoffatom, eine Alkylgruppe, eine Alkenylgruppe, die mit einer oder mehreren Hydroxygruppen substituiert ist, eine Alkenylgruppe, eine Alkenylgruppe, die mit einer oder mehreren Hydroxygruppen substituiert ist, oder eine Alkylgruppe, die mit einer Oxogruppe substituiert ist;
X eine Oxogruppe, (ein Wasserstoffatom und eine Hydroxygruppe), (ein Wasserstoffatom und ein Wasserstoffatom), oder eine Gruppe ist, die durch die Formeln
-CH₂O- dargestellt ist;
Y eine Oxogruppe, (ein Wasserstoffatom und eine Hydroxygruppe), (ein Wasserstoffatom und ein Wasserstoffatom), oder eine Gruppe ist, die durch die Formeln
N-NR¹¹R¹² oder N-OR¹³ dargestellt ist;
R¹¹ und R¹² unabhängig voneinander ein Wasserstoffatom, eine Alkylgruppe, eine Arylgruppe oder eine Tosylgruppe sind;
R¹³, R¹⁴, R¹⁵, R¹⁶, R¹⁷, R¹⁸, R¹⁹, R²² und R²³ unabhängig voneinander ein Wasserstoffatom oder eine Alkylgruppe sind;
R²⁴ ein optional substituiertes Ringsystem ist, das ein oder mehrere Heteroatome enthalten kann;
n eine ganze Zahl von 1 oder 2 ist; und
zusätzlich zu den obigen Definitionen können Y, R¹⁰ und R²³ zusammen mit dem Kohlenstoffatom, mit dem sie verbunden sind, einen gesättigten oder ungesättigten, 5- oder 6-gliedrigen, Stickstoff-, Schwefel- und/oder Sauerstoff-enthaltenden, heterocyclischen Ring darstellen, der optional mit einer oder mehreren Gruppen substituiert ist, die aus der Gruppe ausgewählt sind, die besteht aus einem Alkyl, einem Hydroxy, einem Alkoxy, einem Benzyl, einer Gruppe der Formeln -CH₂Se(C₆H₅)₂ und einem Alkyl, das mit einer oder mehreren Hydroxygruppen substituiert ist;

wobei die Formulierung eine Feststoffdispersionszusammensetzung umfasst, worin die Makrolidverbindung (I) in einem amorphen Zustand in einer wasserunlöslichen Basis vorliegt, wobei die wasserunlösliche Basis, welche in der Feststoffdispersionszusammen-setzung enthalten ist, aus einem wasserunlöslichen Polymer oder Wachs ausgewählt ist.

2. Formulierung mit verzögerter Freisetzung nach Anspruch 1, worin die wasserunlösliche Basis ein wasserunlös-

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liches Polymer ist.

3. Formulierung mit verzögerter Freisetzung nach Anspruch 1, worin die Feststoffdispersionszusammensetzung dadurch gekennzeichnet ist, dass

(1) Lactose oder Calciumhydrogenphosphat als Bindemittel und/oder Gleitmittel enthalten ist,
(2) ein Lösungsvermittler nicht enthalten ist, und
(3) die Partikelgröße der Feststoffdispersionszusammensetzung gleich oder kleiner als 350 \( \mu m \) ist.

4. Formulierung mit verzögerter Freisetzung nach Anspruch 2, worin die Feststoffdispersionszusammensetzung dadurch gekennzeichnet ist, dass das wasserunlösliche Polymer in einer Gewichtsmenge von 0,1 - 5 zu der Verbindung (I) (1,0) vorliegt.

5. Formulierung mit verzögerter Freisetzung nach Anspruch 2, worin das wasserunlösliche Polymer Ethylcellulose oder ein Methacrylat-Copolymer ist.

6. Formulierung mit verzögerter Freisetzung nach Anspruch 5, worin das wasserunlösliche Polymer Ethylcellulose ist.

7. Formulierung mit verzögerter Freisetzung nach Anspruch 2, worin ein wasserlösliches Polymer mit dem wasserunlöslichen Polymer gemischt ist.

8. Formulierung mit verzögerter Freisetzung nach Anspruch 7, worin das wasserlösliche Polymer Hydroxypropylmethycellulose ist.

9. Formulierung mit verzögerter Freisetzung nach Anspruch 8, worin die Feststoffdispersionszusammensetzung dadurch gekennzeichnet ist, dass

(1) die Makrofiddverbindung (I) in einem amorphen Zustand in einer Mischung von Ethylcellulose und Hydroxypropylmethycellulose vorliegt,
(2) Lactose als Bindemittel enthalten ist,
(3) die Partikelgröße der Feststoffdispersionszusammensetzung gleich oder kleiner als 250 \( \mu m \) ist.

10. Formulierung mit verzögerter Freisetzung nach Anspruch 9, worin der Gewichtsanteil der Verbindung (I) zu Hydroxypropylmethycellulose 1 bis 0,2 - 0,4 ist.

11. Formulierung mit verzögerter Freisetzung nach Anspruch 1, worin die wasserunlösliche Basis Wachs ist.


13. Formulierung mit verzögerter Freisetzung nach Anspruch 11 oder 12, worin die Feststoffdispersionszusammensetzung dadurch gekennzeichnet ist, dass

(1) Lactose oder Calciumhydrogenphosphat als ein Bindemittel enthalten ist,
(2) Lösungsvermittler nicht enthalten sind, und
(3) die Partikelgröße der Feststoffdispersionszusammensetzung gleich oder kleiner als 350 \( \mu m \) ist.

14. Formulierung mit verzögerter Freisetzung nach Anspruch 12, die eine Feststoffdispersionszusammensetzung umfasst, welche durch die Verbindung (I) gekennzeichnet ist, die in einem amorphen Zustand in dem Saccharose-Fettsäureester vorliegt, der mit einem Gewichtsanteil von 0,2 - 20 zu der Verbindung (I) (1,0) vorhanden ist.

15. Formulierung mit verzögerter Freisetzung nach Anspruch 12, die eine Feststoffdispersionszusammensetzung umfasst, welche durch die Verbindung (I) gekennzeichnet ist, die in einem amorphen Zustand in dem Glycerinmonostearat vorliegt, das mit einem Gewichtsanteil von 10 - 100 zu der Verbindung (I) (1,0) vorhanden ist.

16. Formulierung mit verzögerter Freisetzung nach Anspruch 12, die eine Feststoffdispersionszusammensetzung umfasst, welche durch die Verbindung (I) gekennzeichnet ist, die in einem amorphen Zustand in dem Polyglycerin-Fettsäureester vorliegt, der mit einem Gewichtsanteil von 0,1 - 100 zu der Verbindung (I) (1,0) vorhanden ist.
17. Formulierung mit verzögerter Freisetzung nach Anspruch 1, worin die Verbindungen (I) die sind, worin jedes der benachbarten Paare von R₃ und R₄ oder R₅ und R₆ unabhängig voneinander eine andere Bindung bilden, die zwischen den Kohlenstoffatomen ausgebildet sind, mit denen sie verbunden sind;

R⁸ und R³² unabhängig voneinander ein Wasserstoffatom sind;
R⁹ eine Hydroxygruppe ist;
R¹⁰ eine Methylgruppe, eine Ethylgruppe, eine Propylgruppe oder eine Allylgruppe ist;

X ein (Wasserstoffatom und ein Wasserstoffatom) oder eine Oxogruppe ist;
Y eine Oxogruppe ist;

die Bindung zwischen den Kohlenstoffatomen ausgebildet sind, mit denen sie verbunden sind;

jedes von R¹⁴, R¹⁵, R¹⁶, R¹⁷, R¹⁸, R¹⁹ und R²² eine Methylgruppe ist;
R²⁴ eine 3-R²⁰,4-R²¹-Cyclohexylgruppe ist,

worin R²⁰ ein Hydroxy, eine Alkoxygruppe, eine Oxogruppe oder eine -OCH₂OCH₂CH₂OCH₃-Gruppe ist, und

R²¹ Hydroxy, -OCN, eine Alkoxygruppe, ein Heteroaryloxy, das mit geeigneten Substituenten substituiert sein kann, eine -OCH₂OCH₂CH₂OCH₃-Gruppe, eine geschützte Hydroxygruppe, Chlor, Brom, Iod, Aminooxalyloxy, eine Azidogruppe, p-Tolyloxythiocarbonyloxy oder R²⁵R²⁶CHCOO ist,

worin R²⁵ ein optional geschütztes Hydroxy oder ein geschütztes Amino ist, und

R²⁶ Wasserstoff oder Methyl ist, oder

R²⁰ und R²¹ in einem Epoxidring zusammen ein Sauerstoffatom bilden; und

n eine ganze Zahl von 1 oder 2 ist.

18. Formulierung mit verzögerter Freisetzung nach einem der Ansprüche 1 bis 17, worin die Verbindung (I) Tacrolimus oder das Hydrat davon ist.

19. Formulierung mit verzögerter Freisetzung nach einem der Ansprüche 1 bis 18, die in Form eines Pulvers, feinen Pulvers, Granulats, Tablette oder einer Kapsel vorliegt.

20. Formulierung mit verzögerter Freisetzung nach Anspruch 1, worin die Zeit (T 63,2 %) 1,0 bis 12 Stunden beträgt.

21. Formulierung mit verzögerter Freisetzung nach Anspruch 1, worin die Zeit (T 63,2 %) 1,3 bis 8,2 Stunden beträgt.

22. Formulierung mit verzögerter Freisetzung nach Anspruch 1, worin die Zeit (T 63,2 %) 2 bis 5 Stunden beträgt.

23. Formulierung mit verzögerter Freisetzung, die eine Feststoffdispersionszusammen- setzung umfasst, welche durch gekennzeichnet ist, dass

(1) Tacrolimus oder das Hydrat davon in einem amorphen Zustand in einer Mischung von Ethylcellulose und Hydroxypropylmethylcellulose vorhanden ist, wobei der Gewichtsanteil der Ethylcellulose und der Hydroxypropylmethylcellulose 0,1 bis 5 beziehungsweise 0,2 bis 0,4 zu Tacrolimus oder dem Hydrat davon (1,0) beträgt,
(2) Lactose als ein Bindemittel enthalten ist,
(3) die Partikelgröße der Feststoffdispersionszusammensetzung gleich oder kleiner als 250 µm ist.

24. Formulierung mit verzögerter Freisetzung nach Anspruch 23, worin der Gewichtsanteil der Ethylcellulose 0,1 - 1 zu Tacrolimus (1,0) beträgt.

25. Formulierung mit verzögerter Freisetzung nach Anspruch 23, worin der Gewichtsanteil der Lactose 2, 3 oder 5 zu Tacrolimus (1,0) beträgt.


27. Formulierung mit verzögerter Freisetzung nach Anspruch 23, worin die Partikelgröße der Feststoffdispersionszusammensetzung gleich oder kleiner als 212 µm ist.

28. Formulierung mit verzögerter Freisetzung, die eine Feststoffdispersionszusammensetzung umfasst, welche da-
durch gekennzeichnet ist, dass

(1) Tacrolimus oder das Hydrat davon in einem amorphen Zustand in einer Mischung von Ethylcellulose und Hydroxypropylmethylcellulose vorhanden ist, wobei der Gewichtsanteil der Ethylcellulose und der Hydroxypropylmethylcellulose jeweils 0,3 zu Tacrolimus oder einem Hydrat davon (1,0) beträgt,
(2) Lactose als ein Bindemittel enthalten ist,
(3) die Partikelgröße der Feststoffdispersionszusammensetzung gleich oder kleiner als 212 µm ist.

29. Formulierung mit verzögerter Freisetzung nach einem der Ansprüche 23 bis 28, die in Form eines Pulvers, feinen Pulvers, Granulats, Tablette oder einer Kapsel vorliegt.

Revendications

1. Formulation à libération prolongée d'un composé de macrolide, dans laquelle le temps (T63,2%) nécessaire pour que 63,2 % de la quantité maximum du composé de macrolide soit dissous est de 0,7 à 15 heures, tel que mesuré selon la pharmacopée japonaise, 13ème édition, Test de Dissolution, No. 2 (Palette tournante, 50 rpm) en utilisant une solution de test qui est une solution aqueuse d'hydroxypropylcellulose 0,005 % ajustée à pH 4,5, dans laquelle le composé de macrolide est un composé tricyclique représenté par la formule générale (I) et un sel pharmaceutiquement acceptable de celui-ci,

\[
\begin{align*}
\text{R}^1 & \text{ est un atome d'hydrogène, un groupe hydroxy, un groupe hydroxy protégé, ou un groupe alcoxy, ou un groupe oxo ensemble avec R}^1; \\
\text{R}^8 & \text{ et R}^9 \text{ sont indépendamment un atome d'hydrogène ou un groupe hydroxy;} \\
\text{R}^{10} & \text{ est un atome d'hydrogène, un groupe alkyle, un groupe alkyle substitué par un ou plusieurs groupes hydroxy, un groupe alcényle, un groupe alcényle substitué par un ou plusieurs groupes hydroxy, ou un groupe alkyle substitué par un groupe oxo;} \\
\text{X} & \text{ est un groupe oxo, (un atome d'hydrogène et un groupe hy-}
\end{align*}
\]

où chacune des paires adjacentes de R1 et R2, R3 et R4, et R5 et R6 indépendamment

(a) est deux atomes d'hydrogène adjacents, mais R2 peut aussi être un groupe alkyle ou
(b) peut former une autre liaison formée entre les atomes de carbone auxquels ils sont liés,
droxy), (un atome d'hydrogène et un atome d'hydrogène), ou un groupe représenté par la formule \(-\text{CH}_2\text{O}\-;\)

est un groupe oxo, (un atome d'hydrogène et un groupe hydroxy), (un atome d'hydrogène et un atome d'hydrogène), ou un groupe représenté par la formule \(\text{N-NR}_1\text{R}_2\) ou \(\text{N-OR}_3\;\)
sont indépendamment un atome d'hydrogène, un groupe alkyle, un groupe aryle, ou un groupe tosyle;

Y est un groupe oxo, (un atome d'hydrogène et un groupe hydroxy), (un atome d'hydrogène et un atome d'hydrogène), ou un groupe représenté par la formule \(-\text{CH}_2\text{O}\-;\)

est un système cyclique éventuellement substitué qui peut contenir un ou plusieurs hétéroatomes;

\(Y\) est un groupe oxo, (un atome d'hydrogène et un groupe hydroxy), (un atome d'hydrogène et un atome d'hydrogène), ou un groupe représenté par la formule \(-\text{CH}_2\text{O}\-;\)

\(R_{11}\) et \(R_{12}\)

\(R_{13}, R_{14}, R_{15}, R_{16}, R_{17}, R_{18}, R_{19}, R_{22}\) et \(R_{23}\)

\(R_{24}\)

\(n\)

e n plus des définitions ci-dessus, \(Y, R_{10}\) et \(R_{23}\), ensemble avec l'atome de carbone auquel ils sont liés, peuvent représenter un hétérocyle contenant de l'azote, du soufre et/ou de l'oxygène, à 5 ou 6 membres saturé ou insaturé éventuellement substitué par un ou plusieurs groupes choisis dans le groupe constitué par un alkyle, un hydroxy, un alcoxy, un benzyle, un groupe de formule \(-\text{CH}_2\text{Se(C}_6\text{H}_5\text{)}\), et un alkyle substitué par un ou plusieurs groupes hydroxy, qui comprend une composition de dispersion solide, dans laquelle le composé de macrolide (I) est présent dans un état amorphe dans une base insoluble dans l'eau, dans laquelle la base insoluble dans l'eau comprise dans la composition de dispersion solide est choisie parmi un polymère ou cire insoluble dans l'eau.

2. Formulation à libération prolongée selon la revendication 1, dans laquelle la base insoluble dans l'eau est un polymère insoluble dans l'eau.

3. Formulation à libération prolongée selon la revendication 1, dans laquelle la composition de dispersion solide est caractérisée par le fait que

(1) un lactose ou hydrogénophosphate de sodium est contenu en tant qu'excipient et/ou lubrifiant,

(2) aucun délitant n'est contenu, et

(3) la taille des particules de ladite composition de dispersion solide est égale à ou plus petite que 350 \(\mu\)m.

4. Formulation à libération prolongée selon la revendication 2, dans laquelle la composition de dispersion solide est caractérisée par le polymère insoluble dans l'eau qui est présent dans une quantité de 0,1 à 5 par rapport au composé (1) (1,0) en poids.

5. Formulation à libération prolongée selon la revendication 2, dans laquelle le polymère insoluble dans l'eau est une éthylcellulose ou un copolymère de méthacrylate.

6. Formulation à libération prolongée selon la revendication 5, dans laquelle le polymère insoluble dans l'eau est une éthylcellulose.

7. Formulation à libération prolongée selon la revendication 2, dans laquelle un polymère soluble dans l'eau est mélangé avec le polymère insoluble dans l'eau.

8. Formulation à libération prolongée selon la revendication 7, dans laquelle le polymère soluble dans l'eau est une hydroxypropylméthylcellulose.

9. Formulation à libération prolongée selon la revendication 8, dans laquelle la composition de dispersion solide est caractérisée par le fait que

(1) le composé de macrolide (I) est présent dans un état amorphe dans un mélange d'éthylcellulose et d'hydroxypropylméthylcellulose,

(2) un lactose est contenu en tant qu'excipient,

(3) la taille des particules de ladite composition de dispersion solide est égale à ou plus petite que 250 \(\mu\)m.

10. Formulation à libération prolongée selon la revendication 9, dans laquelle le rapport en poids du composé (I) sur l'hydroxypropylméthylcellulose est de 1 sur 0,2-0,4.
11. Formulation à libération prolongée selon la revendication 1, dans laquelle la base insoluble dans l'eau est une cire.

12. Formulation à libération prolongée selon la revendication 11, dans laquelle la cire est un monostéarate de glycérine, un ester d'acide gras de polyglycérine ou un ester d'acide gras de saccharose.

13. Formulation à libération prolongée selon la revendication 11 ou 12, dans laquelle la composition de dispersion solide est caractérisée par le fait que

   (1) un lactose ou hydrogénophosphate de calcium est contenu en tant qu'excipient,
   (2) des quelconques délithiens ne sont pas contenus, et
   (3) la taille des particules de ladite composition de dispersion solide est égale à ou plus petite que 350 pm.

14. Formulation à libération prolongée selon la revendication 12, qui comprend une composition de dispersion solide qui est caractérisée par le fait que le composé (I) est présent dans un état amorphe dans un ester d'acide gras de saccharose, dans une quantité de 0,2 à 20 par rapport au composé (I) (1,0) en rapport en poids.

15. Formulation à libération prolongée selon la revendication 12, qui comprend une composition de dispersion solide qui est caractérisée par le fait que le composé (I) est présent dans un monostéarate de glycérine, dans une quantité de 10 à 100 par rapport au composé (I) (1,0) en rapport en poids.

16. Formulation à libération prolongée selon la revendication 13, qui comprend une composition de dispersion solide qui est caractérisée par le fait que le composé (I) est présent dans un état amorphe dans un ester d'acide gras de polyglycérine, dans une quantité de 0,1 à 100 par rapport au composé (I) (1,0) en rapport en poids.

17. Formulation à libération prolongée selon la revendication 1, dans laquelle les composés (I) sont ceux dans lesquels chacune des paires adjacentes de R³ et R⁴ ou R⁵ et R⁶ forment une autre liaison formée entre les atomes de carbone auxquels ils sont liés; chacun de R⁸ et R³² est indépendamment un atome d'hydrogène; R⁹ est un groupe hydroxy;

   R¹⁰ est un groupe méthyle, un groupe éthyle, un groupe propyle ou un groupe allyle;
   Y est un (atome d'hydrogène et un atome d'hydrogène) ou un groupe oxo;
   X est un groupe oxo; chacun de R¹⁴, R¹⁵, R¹⁶, R¹⁷, R¹⁸, R¹⁹ et R²² est un groupe méthyle;
   R²⁴ est un groupe 3-R²⁰⁴-R²¹-cyclohexyle, dans lequel
   R²⁰ est un hydroxy, un groupe alcoxy, un groupe oxo, ou un groupe -OCH₂OCH₂CH₂OCH₃, et
   R²¹ est un hydroxy, -OCN, un groupe alcoxy, un hétéroarylxy qui peut être substitué par des substituants appropriés, un groupe -OCH₂OCH₂CH₂OCH₃, un groupe hydroxy protégé, un chloro, un bromo, un iodo, un aminoxyalcoxy, un groupe azido, un p-toluuidoxyéthoxy, ou R²⁵R²⁶CHCOO⁻, dans lequel R²⁵ est un hydroxy éventuellement protégé ou amino éventuellement protégé, et R²⁶ est un hydrogène ou un méthyle, ou
   R²⁰ et R²¹ ensemble forment un atome d'oxygène dans un cycle époxyde; et
   n est un nombre entier de 1 ou 2.

18. Formulation à libération prolongée selon l'une quelconque des revendications 1 à 17, dans laquelle le composé (I) est le tacrolimus ou son hydrate.

19. Formulation à libération prolongée selon l'une quelconque des revendications 1 à 18, qui est sous la forme d'une poudre, d'une poudre fine, d'un granulé, d'un comprimé ou d'une capsule.

20. Formulation à libération prolongée selon la revendication 1, dans laquelle le temps (T₆₃,₂%) est de 1,0 à 12 heures.

21. Formulation à libération prolongée selon la revendication 1, dans laquelle le temps (T₆₃,₂%) est de 1,3 à 8,2 heures.

22. Formulation à libération prolongée selon la revendication 1, dans laquelle le temps (T₆₃,₂%) est de 2 à 5 heures.

23. Formulation à libération prolongée comprenant une composition de dispersion solide qui est caractérisée par le fait que
(1) le tacrolimus ou son hydrate est présent dans un état amorphe dans un mélange d'éthylcellulose et d'hydroxypropylméthylcellulose dans une quantité de 0,1 à 5 et 0,2 à 0,4 respectivement par rapport au tacrolimus ou son hydrate (1,0) en rapport en poids,
(2) un lactose est contenu en tant qu'excipient,
(3) la taille des particules de ladite composition de dispersion solide est égale à ou plus petite que 250 pm.

24. Formulation à libération prolongée selon la revendication 23, dans laquelle la quantité d'éthylcellulose est de 0,1 à 1 par rapport au tacrolimus (1,0) en rapport en poids.

25. Formulation à libération prolongée selon la revendication 23, dans laquelle la quantité de lactose est de 2, 3 ou 5 par rapport au tacrolimus (1,0) en rapport en poids.

26. Formulation à libération prolongée selon la revendication 23, dans laquelle des quelconques délitants ne sont pas contenus dans la composition de dispersion solide.

27. Formulation à libération prolongée selon la revendication 23, dans laquelle la taille des particules de ladite composition de dispersion solide est égale à ou plus petite que 212 µm.

28. Formulation à libération prolongée comprenant une composition de dispersion solide qui est caractérisée par le fait que

(1) le tacrolimus ou son hydrate est présent dans un état amorphe dans un mélange d'éthylcellulose et d'hydroxypropylméthylcellulose dans une quantité de 0,3 et 0,3 respectivement par rapport au tacrolimus ou son hydrate (1,0) en rapport en poids,
(2) un lactose est contenu en tant qu'excipient,
(3) la taille des particules de ladite composition de dispersion solide est égale à ou plus petite que 212 pm.

29. Formulation à libération prolongée selon l'une quelconque des revendications 23 à 26, qui est sous la forme d'une poudre, d'une poudre fine, d'un granulé, d'un comprimé ou d'une capsule.